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Short Communication

Exploratory Study of Prey Selection by the Invasive Gastropod Rapana venosa (Valenciennes, 1846) in the Río de la Plata Estuary Under Laboratory Conditions

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This study explores the prey selection of the invasive gastropod *Rapana venosa* under controlled laboratory conditions in the Río de la Plata estuary. Under laboratory conditions, the invasive gastropod *Rapana venosa* consumed more individuals of the clam *Erodona mactroides* than of the mussel *Mytilus edulis*; although this difference was not statistically significant, *M. edulis* was consumed in larger biomass quantities. These findings align with optimal foraging theory, emphasizing prey energy profitability and vulnerability. It is important to note that this study constitutes a preliminary exploratory experiment with limited replication, which suggests the need for further research with a higher number of replicates and more varied environmental conditions to draw more robust and generalizable conclusions about the ecological impact of *R. venosa* in the estuary.

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Introduction

Marine ecosystems around the world face numerous ecological threats, but few are as pervasive and impactful as the spread of invasive species. The introduction of non-native species into marine environments can cause complex and often irreversible changes to local ecological networks[1]. Among the multitude of invaders, the gastropod *Rapana venosa* stands out for its rapid proliferation and significant effects on marine biodiversity[2]. Native to the western Pacific (Sea of Japan, the Yellow Sea, and the East China Sea), this carnivorous gastropod has been inadvertently spread by human activities to various coastal regions, including the Mediterranean[2] and the Río de la Plata estuary[3][4][5]. *Rapana venosa* is a large predatory mollusk that preys primarily on bivalves, posing a direct threat to both commercial shellfish populations and the ecological balance of benthic communities[6]. Through its feeding habits, *R. venosa* has the potential to reshape community structures, alter habitat complexities, and influence nutrient cycling processes. Understanding the prey selection of *R. venosa* is a vital component in predicting and managing its impact on marine ecosystems. While some studies have provided initial insights into its dietary preferences[7][8][9][10], a comprehensive analysis of the prey selection behaviors of *R. venosa* in the Río de la Plata estuary is still required. Given the ecological significance and the relatively limited understanding of the feeding ecology of *R. venosa*, this study delves into the dietary

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preferences of the invasive gastropod. By examining its choice of prey under controlled laboratory conditions, this research aims to shed light on key aspects of *R. venosa* predation that could inform targeted approaches to mitigate its impact.

Methods

The experiment was conducted opportunistically, as only three live *Rapana venosa* specimens were captured in the Montevideo harbor, Río de la Plata. Additionally, the institutional bioterium had access to bivalves of both species (*Erodona mactroides* and *Mytilus edulis*), which inhabit the same estuarine habitats[11][12] as *R. venosa*, providing a relevant basis for studying prey selection under laboratory conditions. Specimens of *R. venosa* were collected from the adjacent coastal zone of Montevideo harbor in February 2024 and acclimatized to laboratory conditions over 20 days (20ºC, salinity 20). An experimental design was implemented to discern the prey selection behavior of *R. venosa* under stable conditions of temperature, salinity, and a consistent 12/12-hour light-dark cycle. Regular water changes were performed tri-weekly to maintain optimal water quality. It is worth mentioning that two of the three snails produced egg clutches during acclimatization, so they can be considered adult and female organisms. The experimental setup consisted of three individual 3 L tanks, each housing one snail (mean length 90 mm) without any substrate. Over the 30-day study period, each *R. venosa* specimen was offered a choice of two clams (*Erodona mactroides*) and two mussels (*Mytilus edulis,* a commercially important species in the country) of similar sizes (8 ±4 mm). The consumed organisms were replaced by new live bivalve organisms of the same species at each feeding event. Feeding events were then performed each time the consumption of a new individual was detected, simulating a competitive feeding environment. Additionally, a control tank containing two clams and two mussels, but devoid of snails, was monitored to evaluate the potential for non-predation-related mortality or environmental degradation of prey items. Feeding events were attentively monitored, recording the consumption of prey by direct observational methods and by retrieving the remains of the bivalves, specifically their empty shells (Figure 1). This dual approach allowed for a comprehensive understanding of the feeding behavior and prey preferences of *R. venosa*. The average daily consumption rate (as wet weight) was also estimated for both *E. mactroides* and *M. edulis*. Prey wet weight for biomass consumption estimation was obtained from a separate set of individuals of comparable size to those used in the experiment, since partially consumed prey could not be reliably weighed. To assess whether there was a significant difference in the consumption of the two prey species offered, *E. mactroides* and *M. edulis*, a non-parametric Wilcoxon signed-rank test was employed. This test was chosen due to the experimental design, in which both prey types were simultaneously available on the same dates, allowing for a paired comparison of daily consumption. A non-parametric approach was deemed appropriate as normality in the data distribution could not be assumed.

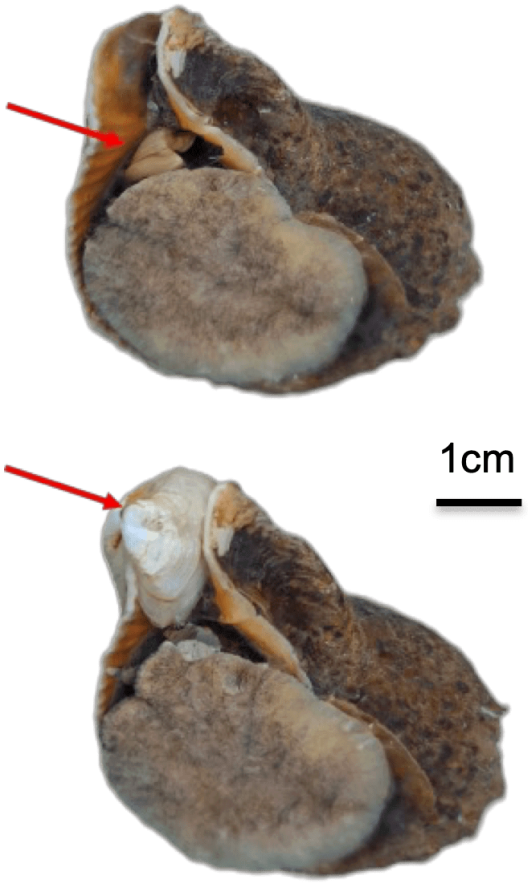

Figure 1. Photographs of a *Rapana venosa* individual feeding on the bivalve *Erodona mactroides*. Note the bivalve almost completely enveloped by the foot (above). Below, release of the empty shells. The red arrow points to the ingested clam.

Results & Discussion

The results indicated that, on average, the three snails examined consumed a notably higher quantity of *E. mactroides* (57%) compared to the intake of *M. edulis* (43%). The Wilcoxon signed-rank test resulted in a test statistic (W = 16.5) with an associated p-value of 0.140, indicating that the observed differences in consumption between the two species are not statistically significant at the 5% significance level. Although the Wilcoxon signed-rank test did not reveal statistically significant differences in daily consumption between *Erodona* and *M. edulis*, the context of the study as an opportunistic and circumstantial experiment warrants a more nuanced interpretation. A consumption preference for *E. mactroides* was consistently maintained throughout the experimental period (Figure 2), suggesting a biologically meaningful pattern. This consistency was evident across all individuals evaluated, each of which exhibited similar percentages of *E. mactroides* consumption relative to *M. edulis* (see Figure 3). Although a consistent pattern of consumption was observed across the three individuals, the lack of statistical significance (p=0.140) means that a definitive prey preference cannot be established from

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this experiment. This observed pattern may, however, warrant further investigation with a larger sample size to determine if a true preference exists.

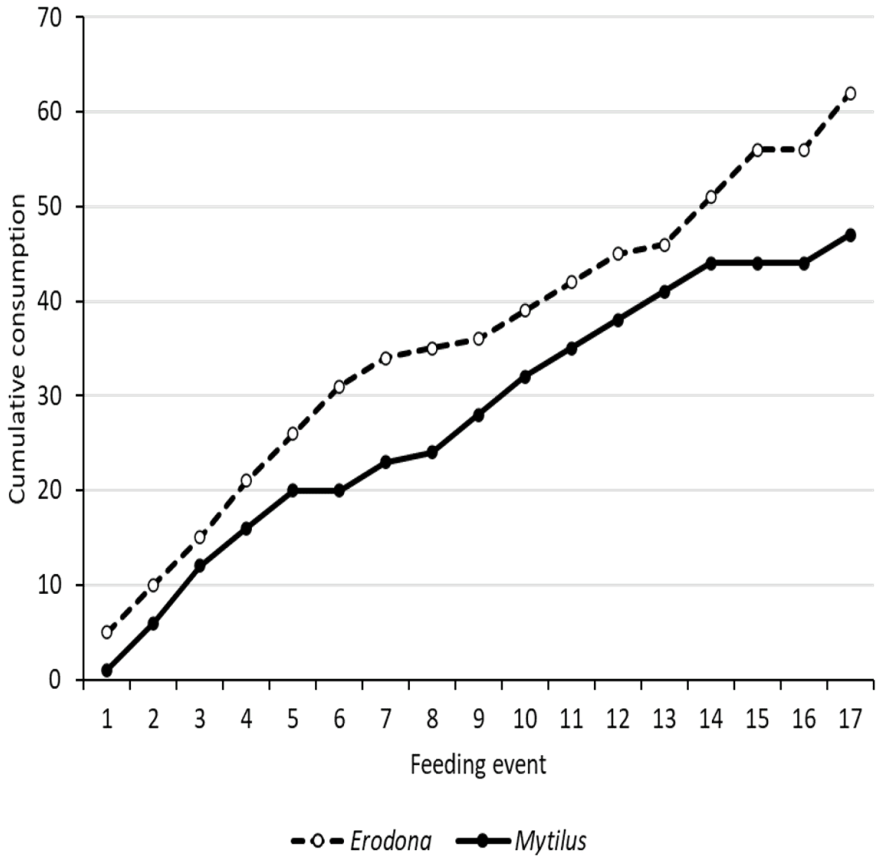

Figure 2. Cumulative consumption (number of animals) of the two bivalve species (*Erodona mactroides* and *Mytilus edulis*) by the *Rapana venosa* snails during the 30-day experiment.

A *R. venosa* specimen of 90 mm average shell length (wet weight = 92 g) ate 0.19 g wwt/day of *E. mactroides* and 0.3 g wwt/day of *M. edulis*; the total daily food ingestion was 0.49 g wwt/day. The control tank without snails exhibited no significant mortality or degradation of the prey items, indicating that any observed consumption of clams and mussels was indeed due to predation by *R. venosa*.

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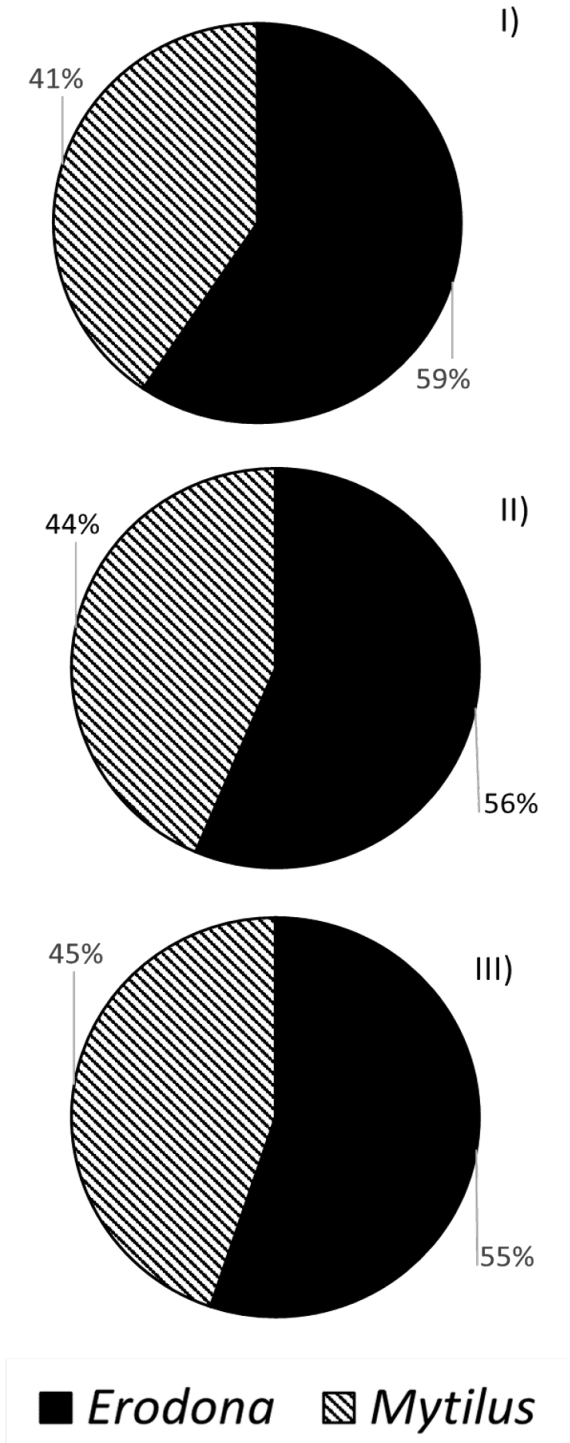

Figure 3. Consumption preference (%) of each of the three individual *Rapana venosa* snails for each of the two bivalve species (*Erodona mactroides* and *Mytilus edulis*) offered during the 30-day experiment.

The findings of this study permit the discussion of the prey selection preferences of *R. venosa* in a controlled feeding environment. The results suggest a preference for the clam

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E. mactroides over the mussel *M. edulis*, with the gastropods consistently consuming a higher quantity of *E. mactroides* than *M. edulis*. However, in terms of total biomass consumed daily, the gastropods may ingest a greater mass of *M. edulis* compared to *E. mactroides*. These results suggest that while *R. venosa* shows a preference for *E. mactroides* as a food source, it can still consume significant quantities of *M. edulis* when available, though statistical evidence is lacking and further studies are needed. This discrepancy can be interpreted through the lens of optimal foraging theory[13], which posits that predators maximize their net energy intake by selecting prey that offers the best trade-off between handling time and energy gain.

The potential predation of *R. venosa* on *E. mactroides* (and other native clam species in the Río de la Plata) has been previously noted due to their overlapping distribution within the estuary[14] and by laboratory experiments[8]. Although our test is not directly comparable due to differences in conditions and the food supply provided to *R. venosa*, our results align with those reported by Giberto[8] regarding the intake of *E. mactroides* and *M. edulis* by *R. venosa*. However, we observed differences in bivalve preference; in our study, *E. mactroides* were preferred, whereas Giberto[8] reported a major preference for *M. edulis*. These results agree with previous similar experiments in different systems and with different prey species[6][9]. *R. venosa* exhibited similar prey selection and foraging behavior when offered clams, mussels, and oysters, preferring clams, probably due to their higher energy content and easier capture, consistent as mentioned with optimal foraging theory. Mussels were second in preference, while oysters, with their stronger shells, were the least selected. This suggests that prey selection is driven by energy profitability and prey vulnerability[15]. The preference for certain food may be explained by a foraging strategy that maximizes net energy gain, meaning the gastropods select prey that can be captured and consumed more quickly than other available species[6]. If this theory applies in this context, clams such as *E. mactroides* might be favored due to their higher energy content and profitability, which could partially explain the observed consumption pattern. In this sense, in addition to species preferences, prey selection by size could also play a role in *R. venosa* consumption patterns. Although our experiment did not vary prey size, previous studies[9] have shown that gastropods of all sizes consume significantly more medium-sized (20-30 mm) than small-sized (15-19 mm) mussels. This highlights the importance of size in prey selection and adds another layer of complexity in evaluating the potential effects of *R. venosa* on invaded ecosystems. The impact of prey selection on *E. mactroides* populations and cascading effects in the Río de la Plata ecosystem may be marginal, as *E. mactroides* is estuarine and leans toward freshwater habitats, while *R. venosa* tends to inhabit mixohaline areas, suggesting limited spatial overlap. However, this has not been extensively studied.

It is important to note that this study presents several logistical limitations that restrict replication and the scope of the findings. The limited number of *R. venosa* specimens (3) and the small size of the experimental tanks contribute to the exploratory nature of the study. As such, caution should be exercised when extrapolating these results to field conditions. The findings reflect the behavior of a small sample size under controlled laboratory conditions, which may not fully capture the complexity of predator-prey interactions in natural environments, where factors such as habitat variability, prey availability, and environmental fluctuations could significantly influence prey selection by *R. venosa*. Laboratory settings do not account for ecological variables such as competition or environmental stressors, which are prevalent in field conditions. Given these limitations, it is crucial to recognize the challenge of extrapolating these laboratory results directly to natural systems. The controlled conditions of this study, such as constant temperature and salinity, do not replicate the variability seen in nature, so field validation of prey preferences is important. Additionally, in the estuarine environment, prey species like *E. mactroides* and *M. edulis* are distributed across different habitats, influenced by environmental gradients such as salinity and substrate type (soft and hard substrate)[11][12]. To build on this preliminary work, complementary field studies are

necessary to evaluate *R. venosa*'s prey preferences in natural conditions. Regional studies on the spatial overlap of *R. venosa* and its prey, such as those by *Giberto et al.*[14] and *Lanfranconi et al.*[9], could provide insights into how environmental variability influences predator-prey dynamics. Such studies will be critical to understanding the broader ecological impact of this invasive species in estuarine ecosystems.

Study limitations

The main limitation of this study lies in its small sample size (n = 3), a constraint imposed by the opportunistic nature of specimen collection. This limited replication reduced the statistical power of our analysis, and consequently, the observed differences in prey consumption were not statistically significant (Wilcoxon signed-rank test, $p = 0.140$). Therefore, no definitive conclusions can be drawn regarding the dietary preferences of *Rapana venosa* based on the present data, as the observed difference did not reach statistical significance at the conventional threshold ($p < 0.05$). However, the p-value obtained ($p = 0.140$) suggests a potential trend that may warrant further investigation with a larger sample size. Nevertheless, this study represents the first quantitative, albeit preliminary, assessment of the feeding behavior of *R. venosa* in the Río de la Plata estuary. These initial observations provide valuable insights for generating testable hypotheses and establishing a foundational reference for future research. Larger-scale experimental studies with greater replication and environmental variability will be essential to robustly evaluate prey selection patterns and the broader ecological implications of this invasive species in estuarine ecosystems.

Statements and Declarations

Ethics

This study involved laboratory observations of *Rapana venosa*, *Erodona mactroides*, and *Mytilus edulis*, all of which are marine invertebrate species. According to local norms on animal experimentation (Uruguayan Law No. 18.611, 2009, Article 31), ethical review procedures apply exclusively to species classified within the phylum Chordata, subphylum Vertebrata. Therefore, no formal ethical approval was required for this research. Nevertheless, all experimental procedures were conducted in accordance with the laboratory protocols and ARRIVE (Animal Research: Reporting of In Vivo Experiments) guidelines[16], ensuring the humane treatment of the organisms and minimizing stress during acclimatization and observation.

Data Availability

The raw data supporting the conclusions of this article are available from the authors upon reasonable request. Inquiries can be directed to the corresponding author.

Author Contributions

Conceptualization: D.L., E.B.O.; Methodology: D.L.; Investigation: D.L.; Formal analysis: D.L.; Resources: E.B.O.; Data Curation: D.L.; Writing – original draft: D.L.; Writing – review & editing: D.L., E.B.O.; Supervision: E.B.O.; Funding acquisition: E.B.O.

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Declarations

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