

**Examining the relationship between Olfaction and Prey Preference
in *Cancer productus***

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ABSTRACT

Olfaction plays an important role in crustacean foraging behavior, but its influence on prey selection in *Cancer productus* remains poorly understood. We tested whether red rock crabs exhibit olfactory preferences between two *Nucella* species and found no significant overall preference, although crab size was associated with differences in prey choice, suggesting that individual traits may influence olfactory-mediated foraging behavior.

INTRODUCTION

Olfaction is critical to a variety of biological processes observed in crustaceans, including navigating landscapes and settlement (Brooker & Dixon 2017) detecting predators, hunting prey, and locating mates (Rosen et al. 2009; Jones et al. 2024). Studies show that crabs distinguish objects by the presence of prey-scent (Rebach 1996), and lengthened exposure to predator scents heighten reception of future prey scents (Burnett et al., 2026). Mating behavior is also heavily mediated by the presence of chemical signals and their ability to detect them (Jones et al. 2024).

In addition to their socioeconomic importance as fishery species, crabs are important ecological predators, providing crucial biotic resistance from invasive species such as *C. maenas* (Hunt & Yamada 2003), and helping to manage ecosystems in a top-down method (Hull & Bourdeau 2017). Research has also shown preferences in crab feeding, specifically in *Cancer productus*, a recreational crabbing species known for voraciously consuming shelled gastropods and bivalves (Barclay et al. 2020; Dudas et al. 2005; Smith et al. 1999).

Analysis of feeding choices in *C. productus* shows a preference for prey with the highest benefit-cost ratio, the caloric gain to loss of energy, signaling some sort of decision making and effort analysis (Nicol et al. 2026). Additional studies found preference of *Nucella lamellosa* compared to other *Nucella* species in a multiple-choice experiment, with the feeding preference attributed to size difference in species (Barclay et al. 2020). Further analysis into preferential feeding has yet to examine the potential of chemosensory cues to impact predatory choices.

Concern for olfactory mediated behaviors remain a heavily researched subject, recently due to the changes in ocean pH caused by anthropogenic climate change. The consequences of ocean acidification have cascading effects, notably reducing the effectiveness of chemosensory receptors in crustaceans. European green crab (*Carcinus maenas*) olfaction showed significant loss of sensitivity when exposed to lower pH, reducing hormone receptiveness and mate finding, and subsequent behavior (Jones et al. 2024).

How these changes will affect red rock crab foraging is relatively understudied, along with olfactory specifics in *C. productus* hunting. In an effort to address this knowledge gap, red rock crabs were blindly subjected to chemical cues from different gastropod species in the genus *Nucella* and recorded the choices determined by olfaction.

MATERIALS & METHODS

Twelve *C. productus* individuals were collected from the FHL docks (48.5453, -123.0121) using cat food-baited crab traps. Crabs were contained in sea tables with constant flow of Natural Sea Water (NSW) and fed scallops outside of the scope of the experiment. Crabs were unfed for a maximum of seven days prior to testing, which is consistent with existing literature (Barclay et al., 2020).

Two *Nucella* species were collected from Cattle Point on San Juan Island (48.450668, -122.96336) and kept in flowing sea water tables until trials began. *N. lamellosa* was chosen due to previous studies suggesting preference (Barclay et al., 2020) and commonality in the low intertidal where *C. productus* more commonly hunts, while *N. ostrina* was chosen due to its small size, and location in the high intertidal.

Testing was conducted in opaque filled sea tables without flowing water for the duration of the experiment. Preceding trials, the sea table was filled, perforated prey containers and vision screens (Fig. 1) were placed against the far walls, and barriers were placed opposite them to create a corner for the crab to start in. An individual rock crab was then placed in between the barriers and observed for up to 15 minutes. Preference choices were counted as prey box bumps, where contact with the containers was considered choosing that box. Following the initial choice, crabs were observed for three minutes for consistency, allowing the prior time in the tank to primarily consist of acclimation and scent detection.

Following each trial, full water changes were performed, including scrubbing of all surfaces to eliminate residual scent cues from influencing sequential trials. Prey containers were moved to opposite corners between trials to ensure randomization of scents and reduce the potential for a side bias.

Snail and no-snail controls were performed following experimental trials. A prey box containing individuals of either *N. ostrina* or *N. lamellosa* was placed in one corner and an empty

prey container was placed in the other. Controls were observed for a maximum of 15 minutes, and only the first choice was recorded. If no choice was made (container bump), the trial was omitted due to lack of data. Snail and no-snail boxes were swapped every trial, and full water changes were completed between each trial, along with scrubbing the sea table.

Following the first 11 trials, three of which were omitted due to unsuccessful data collection, an acclimation and release device was added to the system to improve collection accuracy, establish a relative acclimation period, and reduce stress or defense behaviors. The device consisted of an overturned colander, a weight affixed on top, and ropes connected to a pulley system. Crabs were placed under the colander after the sea table was filled and allowed to acclimate for five minutes as the trial was set up around them. Once acclimated, the device was slowly raised, and the observational period began.

Results were analyzed using a Shapiro-Wilk normality test to assess distribution, and based on the results, either a paired t-test or Wilcoxon signed rank test was performed using RStudio Version 2025.09.0+387.

RESULTS

Snail and no-snail controls yielded no statistical significance, with five out of the nine *N. ostrina* tests and four of the seven *N. lamellosa* tests choosing the snail box, resulting in 55% and 57% respectively choosing snail over no snail (Fig. 2, Fig. 3).

Overall preference between *N. ostrina* and *N. lamellosa* was observed to be relatively similar, with slightly more spread in the frequency of container bumps in *N. lamellosa*, but significant overlap between the two species (Fig. 4). Distribution was not normal, and a Wilcoxon signed rank test resulted in an insignificant p-value of 0.5807.

Snail preference by crab carapace width was graphed (Fig. 5) displaying some overlap between the first and second quartile of the *N. lamellosa* trials and the first three quartiles of the *N. ostrina* quartiles, displaying container bumps by crabs between 14 and 16 cm. *N. lamellosa* had a larger spread, with more container bumps from medium to small crabs compared to *N. ostrina*, which except for occasional small crab interactions, was restricted to mostly larger crabs. A paired t-test was performed due to the normal distribution, yielding a p-value of 0.002233. A Wilcoxon signed rank test was also performed as an added measure of redundancy, resulting in a p-value of 0.005264, further supporting the significance of these results.

DISCUSSION

The results from the control and feeding preference suggest that an olfactory cue mediating prey selection shows limited support for the hypothesis that olfaction mediates prey preference between snail species. While there was a slight trend to more snail choices than no-snail choices, it was insignificant, and the general preference test offered no direct support for snail preference overall from the species *C. productus*.

The carapace width results display some potential for individual crab preference to snail species preference. The significant relationship between carapace width and prey choice suggests that crab size may influence responses to prey-derived chemical cues. Based on the combined results, the data is not sufficient to reject the null hypothesis.

Possible reasons for a trend in larger carapace widths preferring to approach scent cues from *N. ostrina* could be in part to a benefit-cost ratio difference seen in smaller vs larger crabs (Nicol et al., 2026). This proposed difference could be impacting the crabs decisions, as hunting is individually dependent on the size of the hunter. Further research could be done to assess the possibility of a stronger olfaction preference for snail species depending on individual crabs size. If one exists, it could explain for the lack of significance from the control trials. Due to the limited sampling, not every crab was able to be tested in each control or didn't respond to the stimuli. Given the limited sample size, this result should be interpreted cautiously and warrants further investigation with a larger number of individuals.

The potential for olfaction to navigate prey detection and preference stems from existing research supporting their ability to differentiate food and non-food items via olfaction (Rebach 1966), and a previous understanding of food preference (Barclay et al., 2020), with possible influence from benefit-cost ratios (Dudas et al., 2005, Smith et al., 1999, Nicol et al., 2026). Despite the lack of clarification on the use of olfaction in determining prey selection, the results from the carapace width analysis exposes further gaps in existing research. Understanding the extent of information crabs receive from olfaction is crucial in cognizing how they perceive their

environment. Due to their importance as predators, impacting food webs similar to keystone predators (Hull et al., 2017), and reducing the establishment and spread of novel organisms (Hunt and Yamada 2003), understanding the factors that drive their foraging habits is vitally important. Similarly, understanding the role these crabs play throughout their different life stages, and how these factors change is also necessary to ensure healthy ecosystems (Dudas et al., 2005, Nicol et al., 2026).

Although olfactory cues alone did not explain prey preference between *Nucella* species, the observed relationship between crab size and cue response suggests that foraging decisions may vary across life stages. Further investigation into size-dependent prey selection and olfactory perception will improve our understanding of predator-prey interactions in intertidal ecosystems and how they may respond to future environmental change.

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FIGURES

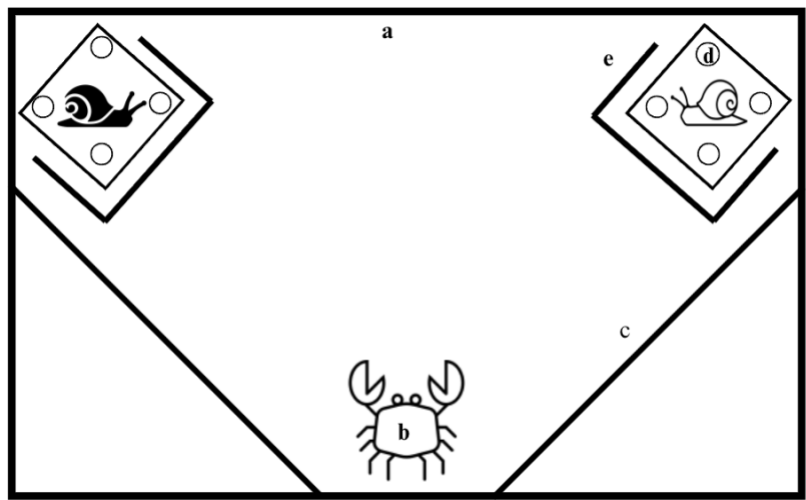


Figure 1. Experimental setup for multiple *Nucella* trials. (a) Sea table (b) Crab starting position (c) Side barrier inserts (d) Perforated prey container (e) Visual screen

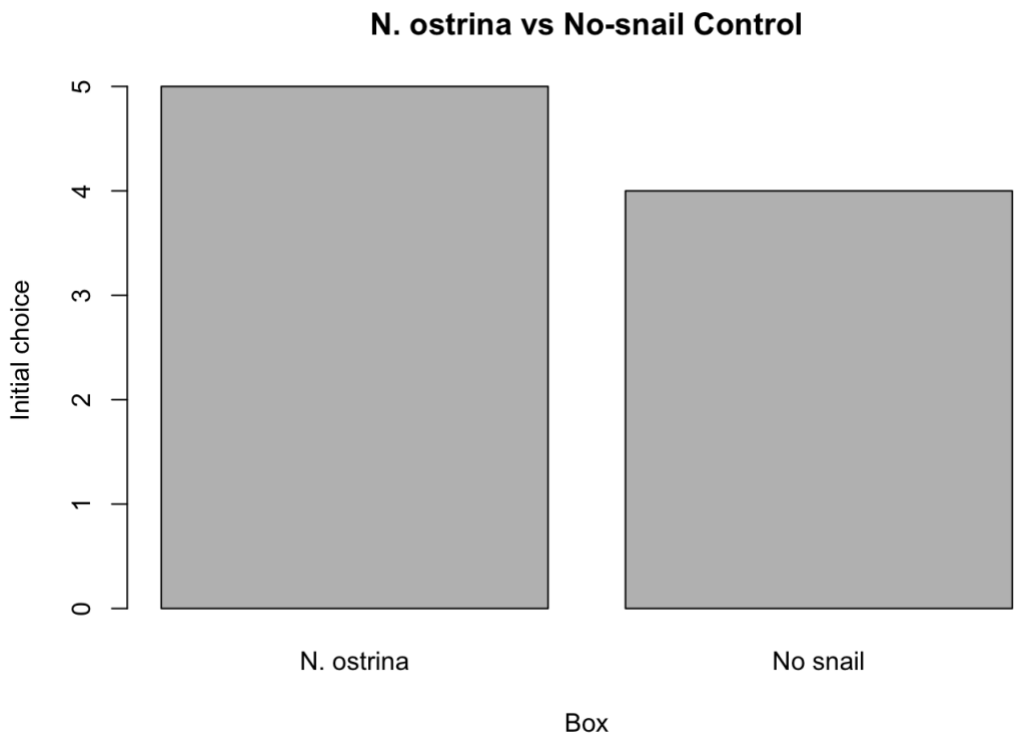


Figure 2. *N. ostrina* control with no snail box. Initial decision (container bump) along the y-axis. 55% of trials resulted in choosing the snail box.

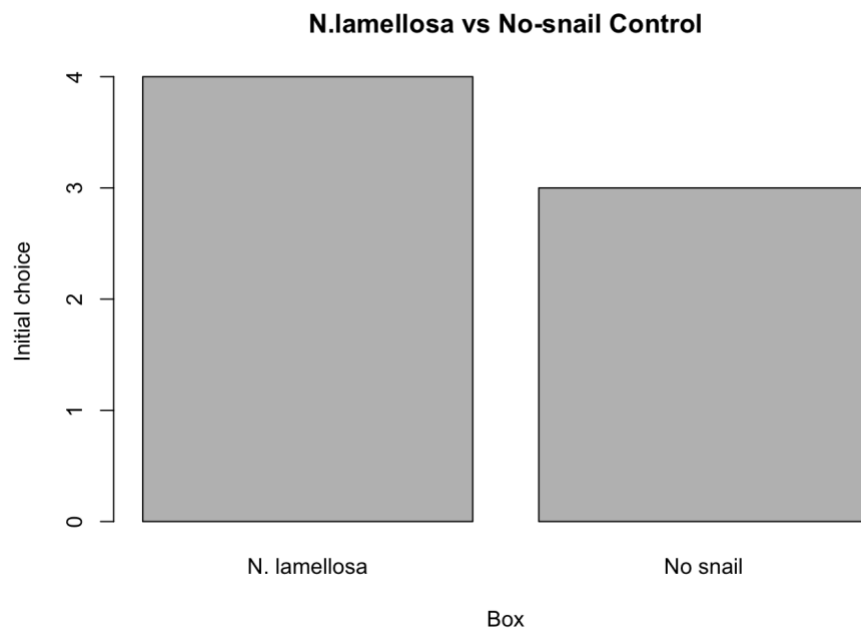


Figure 3. *N. lamellosa* control with no snail box. Initial decision (container bump) along the y-axis. 57% of trials resulted in choosing the snail box.

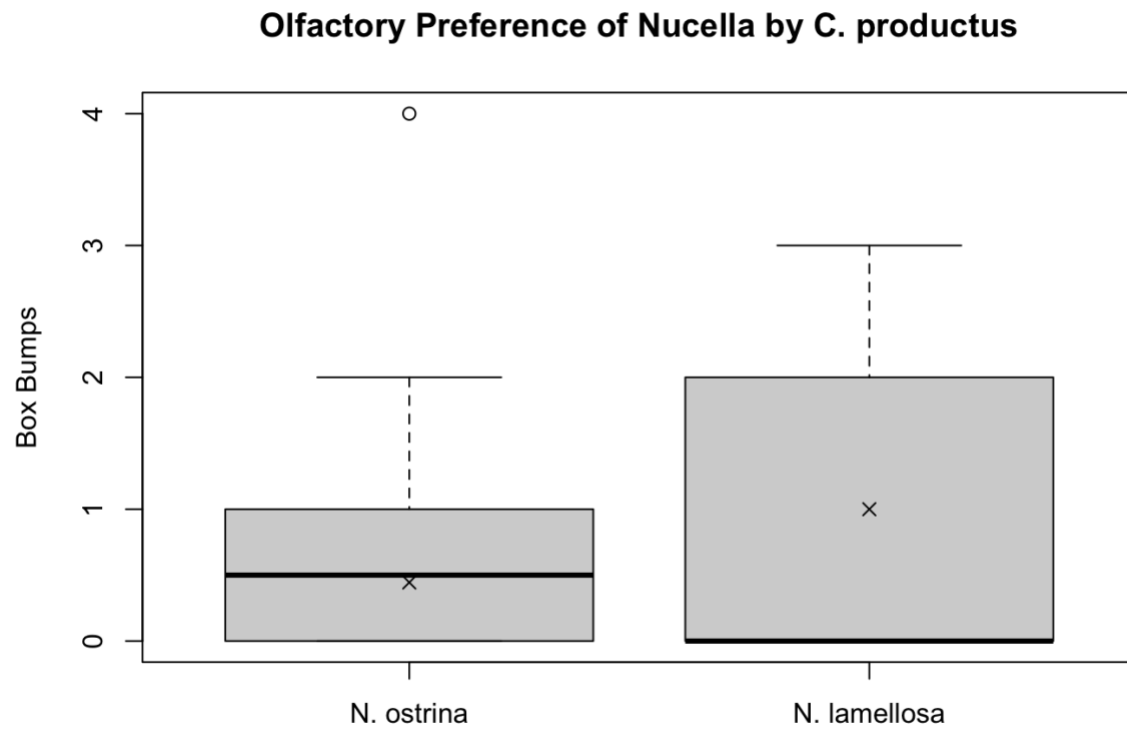


Figure 4. Olfactory preference towards *Nucella ostrina* and *lamellosa* by *Cancer productus*. Box bumps per trial listed on the y-axis and species on the x-axis. Wilcoxon signed rank p-value of 0.5807. Wider spread of *N. lamellosa* compared to *N. ostrina*, but with no statistical significance.

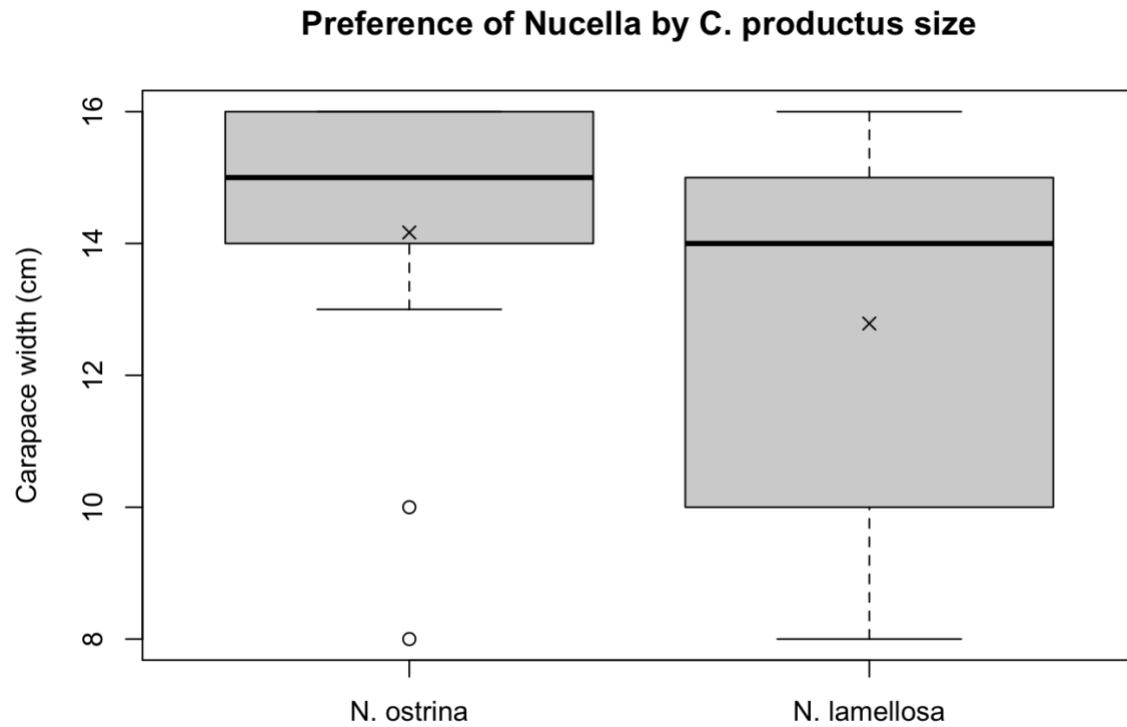


Figure 5. Olfactory preference of *Nucella ostrina* and *lamellosa* by carapace size. Prey container bumps by carapace size on the y-axis. Higher concentration of bumps in *N. ostrina* with a lower spread compared to *N. lamellosa*. Paired t-test p value of 0.002233, and a Wilcoxon signed rank: p-value of 0.005264.