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ABSTRACT

Hemigrapsus sanguineus, commonly known as the Asian shore crab, was first discovered on the east coast of the United States in New Jersey in 1988. The spread of this invasive crab has been rapid, and it is now abundant along a large portion of the mid-Atlantic and southern New England coast. Further, an invasion of *H. sanguineus* into New Hampshire and southern Maine is in its preliminary stages. The introduction of this crab to North America could potentially affect a variety of native species.

Numerous studies have examined the predation of *H. sanguineus* on blue mussels, snails, and other bivalves. In this study, we consider the predation of *H. sanguineus* on juvenile *Homarus americanus* (American lobster). We conducted laboratory experiments to investigate whether *H. sanguineus* can and will consume juvenile *H. americanus*. These trials affirmed that invasive crabs do prey on lobsters even when the crabs were provided other food alternatives and the lobsters were given shelter. Further research is necessary to evaluate if there exists a real or potential threat to the juvenile *H. americanus* population in the wild.

INTRODUCTION

Hemigrapsus sanguineus, commonly known as the Asian shore crab, is a brachyuran crab, indigenous along the western North Pacific coast (Brousseau et al. 2001). It was first discovered on the east coast of the United States in New Jersey in 1988 (Lohrer 2001). By 1998 this newly introduced crab ranged from North Carolina to New Hampshire (McDermott 1998). It was identified in southern Maine in 2001 (Lohrer 2001). Since its earliest sighting, *H. sanguineus* has become abundant along a large portion of the mid-Atlantic and southern New England coast (Lohrer 2001).

Whether the habitats of *H. sanguineus* and juvenile *H. americanus* overlap is a critical question. If *H. sanguineus* habitat does *not* overlap with significant juvenile *H. americanus* habitat, then the predation experiments conducted in this research are academically interesting, but have no real impact on the health of the lobster population in the short term. It is generally reported (Cobb and Phillips 1980) that lobsters are found from the low tide mark out to depths of approximately 400 m, with higher concentrations in shallower water. However, researchers (Wahle and Steneck 1991; Ellis and Cowan 2001) are not in agreement as to just how abundant the juvenile *H. americanus* population is in the lower intertidal and upper subtidal zones.

Hemigrapsus sanguineus are thought to descend into the subtidal zone, especially in the winter (Lohrer 2001). But how deep they travel and in what quantities are not documented. There is at the very least potential for *H. sanguineus* and juvenile lobsters to overlap (see Figure 1). Both species prefer a cobble environment, and both species have been shown to cross the intertidal/subtidal line. At a minimum, juvenile lobsters and *H. sanguineus* overlap at their most extreme ranges. Changing dynamics such as water temperatures or further *H. sanguineus* adaptation have the potential to influence future patterns of overlap.

While competition for space may indirectly increase predation on juvenile lobsters by forcing them from hiding spots (Jensen et al. 2002), this research will address whether *H. sanguineus* is a predator on juvenile *H. americanus*. There has been speculation that the capture and consumption of juvenile *H. americanus* may be too arduous a task for these crabs, especially when less agile prey are present in the same environment thereby making the capture of juvenile *H. americanus* not as profitable for the crabs. Thus, it will first be addressed if crabs can prey on lobsters, and then secondly if crabs will prey on lobsters when other foodstuffs are available.

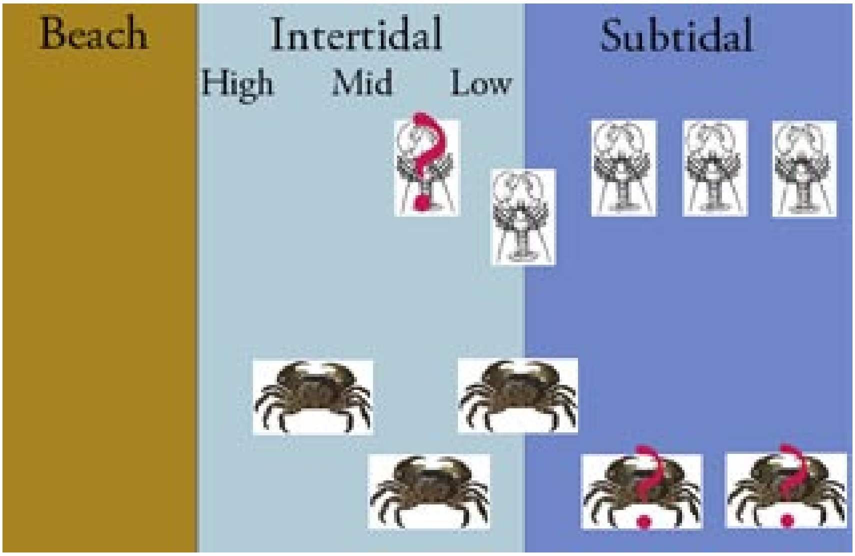

Figure 1. Potential habitat overlap of *Hemigrapsus sanguineus* and *Homarus americanus*.

METHODS

The purpose of this research is to examine the following question: can and will *H. sanguineus* prey on juvenile *H. americanus*? There were two parts to the project, a preliminary study to establish the existence of a predatory relationship, followed by an in depth quantitative investigation of this relationship. Both experiments were conducted at the aquaculture facility at the University of Maine in Orono. A four-tank closed system equipped with a bio-filter and chiller was used for housing the animals as well as conducting the experiments.

Experiment 1: Can *H. sanguineus* Prey on *H. americanus*?

Hemigrapsus sanguineus, collected at the mouth of the Nissequogue River in Long Island, New York, were placed into separate 19-L, white plastic containers with a single *H. americanus,* obtained from the University of Maine in Machias. Three trials of six separate crab/lobster pairs per trial were conducted over the course of the study. All trials were conducted in a large rectangular tank, which held six containers and each container had its own aerator. Shelter was provided for the lobsters by means of two overturned halves of mussel shells. A piece of a clam was placed in each container as an alternative food source for the crab. Lids were placed on each of the containers to ensure darkness and to prevent escape. Figure 2 is a picture of an experiment being set up with containers, aerators and lids. Observations of each container were taken every 5 minutes for the first 15 minutes and then after 2 hours and then not again until the end of the experiment.

Crabs ranged in size from 14.6 to 24.9 mm carapace width (CW). The lobsters ranged from developmental stage five through stage seven. Prior to the experiment, crabs were fed canned and

Figure 2. Experiment setup for preliminary study.

fresh clams *ad libitum* while the lobsters were fed salmon pellets and brine shrimp. Crabs were fed within 48 hours, but not 24 hours before being used in a test. Water temperature was kept between 12.2 and 14.4°C. The salinity of the water varied from 26 to 29 ppt over the course of the experiments. Crabs and lobsters were each used only once in the study, and only crabs with both claws intact were used.

Experiment 2: Will *H. sanguineus* Prey on Juvenile *H. americanus* in a More Realistic Setting?

Four identical mesocosms, each 0.25 m^2, were constructed. Each mesocosm was designed to replicate a shallow, subtidal, cobble (rocky) environment with seaweed and mussels. *Hemigrapsus sanguineus* used in the experiments were collected by hand from Sandwich Town Beach on Cape Cod and Manchester Beach in Massachusetts. Crabs ranged in size from 18 to 29 mm CW. Juvenile lobsters, primarily stage six lobsters (11–15 mm CL), were produced at the New England Aquarium hatchery, and blue mussels (*Mytilus edulis*, 10–34 mm shell length) were collected on Mount Desert Island, Maine. The water temperature in each tank was kept at approximately 18°C and the salinity at 33 ppt.

Each mesocosm was constructed by layering three levels of cobble. The cobble ranged in diameter from 80 to 110 mm and was mostly spherical in shape, which is typically the preferred habitat of juvenile lobsters in subtidal environments (Wahle and Steneck 1991). A circulating system was created by running saltwater into each tank through an input valve and out the other end of the container through a 2-inch-diameter hole located above the cobble. A fine wire mesh was affixed to the output hole to keep the lobsters and crabs from escaping.

Small holes drilled in the intake pipe created simulated currents throughout the tank. The lobsters were fed with baby brine shrimp that flowed through the tanks on these simulated currents. In this way they received food without having to leave the protection of shelter to forage, as would be the case in the wild.

Four lobsters were used in each mesocosm test, simulating natural lobster densities in habitat with complete cobble cover (Wahle and Steneck 1991). However, Wahle and Steneck (1991) questioned whether the densities they found were due to a lack of numbers of animals or because of special requirements of lobsters that are not yet understood. Therefore, as a precaution, four lobsters were placed in one of the tanks and left for three days prior to beginning the experiments. They were fed brine shrimp through the simulated current system. This was a test to ensure that the lobsters were getting enough food and had enough room so that they would not prey on each other.

After these initial tests, three separate sets of trials were performed. In the first two trial sets all four mesocosms were used. In the third trial set only two of the mesocosms were used giving a total of 10 mesocosms used (each with four lobsters and one crab).

Blue mussels and seaweed were placed in the mesocosm as alternative food sources for the crab, and as additional shelter for the lobsters. Every effort was made to ensure the four mesocosms were setup as similarly as possible. The four lobsters were placed in the mesocosm prior to the crab to give them time to acclimate and find shelter. After this, one adult male crab was introduced to each tank. To standardize hunger levels, crabs were fed between 24 to 48 hours before each trial. All crabs used in the testing were male and each crab was used only once.

Each test was conducted for 48 hours. At the end of the test period, all of the cobble and seaweed was methodically removed from each tank and an inventory of live lobsters and mussels was taken. The amount of seaweed consumed by the crabs could not be accurately quantified. It is generally accepted that some 60% of *H. sanguineus* diet comes from non-animal sources (Lohrer and Whitlatch 2000).

RESULTS AND DISCUSSION

In experiment 1, crabs consumed the lobsters in 17 out of 18 (94%) trials. Of the 17, 10 were devoured within 2 hours of placing the animals together. Figure 3 shows a crab in the process of consuming a lobster.

When crabs were put in a more natural setting with alternative foodstuffs (mussels and algae), as was done in the second experiment, *H. sanguineus* did in fact consume juvenile lobsters. Thirty-one of the 36 lobsters (86%) in the study were eaten, equal to an average consumption rate of 3.44 lobsters per mesocosm bounded by a 95% confidence interval. However, there were an insufficient number of trials to draw any further conclusions about the possible predatory relationships between the two species such as the relationships between crab size and predation as well as between size difference between prey and predator.

Figure 3. A crab eating a lobster.

In all of the trials there was at least one mussel left in the tank at the end of the experiment. Almost without exception the remaining mussels had a shell length greater than 18 mm. Large size is likely the reason these mussels survived. If this is the case, then the obvious next question is what would the results have shown had more juvenile mussels been available? Would they have been consumed before or even instead of the juvenile lobsters? Just how many mussels and lobsters would a single crab eat if there were in fact an abundant supply of small mussels? Additionally, this study was designed to look at the raw number of each type of prey consumed rather than the proportionate weight contribution of each type of prey to the crabs overall diet. Analyzing the percentage of weight an individual prey contributes to the crab's daily diet may prove to be a more accurate measurement of prey selection especially if a more varied selection of prey were used.

CONCLUSIONS AND RECOMMENDATIONS

This study should be seen as a first step in understanding the relationship between *H. sanguineus* and juvenile *H. americanus*. The results show that this invasive crab species will consume juvenile lobsters, even when alternative foodstuffs were available. However, this study should not be taken as evidence that the lobster population is at risk due to such an invasion. Rather it opens up this possible scenario for future investigation. More research needs to be conducted to understand the many questions that still need to be answered with regard to this topic: what will happen in areas where *H. sanguineus* and juvenile *H. americanus* habitat overlap? Will the lobsters simply move into deeper water out of the range of the crabs? Will the crab's presence force the lobsters from needed shelter and open them up to other prey? In a more natural environment, would the lobster be able to outrun, outmaneuver or hide from the crab? Given more food choices would the crab still find it profitable to prey on a juvenile lobster?

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