CARCINUS MAENAS: A DEMOGRAPHIC STUDY OF AN INVASIVE SHORE CRAB IN THE NEW ENGLAND ROCKY INTERTIDAL

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Abstract:

Carcinus maenas (Green Crab) is an invasive crab species on the east and west coasts of the United States dating back to 1817. The introduction of another invasive species in 1988, *Hemigrapsus sanguineus* (Asian Shore Crab), has created competitive interactions between the crabs. A demographic study was conducted to compare crab populations. A total of 155 crabs were collected, 25 of which were *C. maenas* and 130 *H. sanguineus*. There are significantly more male Green Crabs (21) than female Green Crabs (4) ($p>.0001$). There are also significantly more female Asian Shore Crabs (81) than males (49) ($p>.0001$). Correlations between width and limb loss also exist such that as the width of the Asian Shore Crab carapace increases, the number of autotomized limbs increases ($p>.0001$). These results lead to important questions and further studies regarding competition between these invasive species.

Keywords: *Carcinus maenas,* Green Crab, *Hemigrapsus sanguineus,* Asian Shore Crab

Introduction:

Carcinus maenas, the Green crab, in an invasive shore crab originating from Europe and Northern Africa. First recorded on the Atlantic coast of the United States in 1817, it has since successfully invaded the east and west coasts. *C. maenas* is a small shore crab, measuring about 75mm across as an adult. The dorsal side of the carapace ranges from a dark green to brown with yellow patches. The ventral side can be green, yellow, orange, or red. Its most distinguishing feature is the five triangular spines located to the outside of both eyes (Fig. 1).

Fig. 1: *Carcinus maenas* in small sampling bucket

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An omnivore, the Green Crab feeds on mussels, clams, snails, polychaetes, isopods, barnacles, algae, and other crabs. It can be found in quite abundance in estuaries, sheltered intertidal zones, and shallow sub-tidal habitats (Mathews et al., 1999). Specifically, these crabs can be found under rocks, algae and in tide pools (Pollack, 1999). Mating between July and September, the female Green Crab will typically reproduce twice in one season, spawning upwards of 185,000 eggs each time (Prince William, 2004). Green Crabs go through six larval stages, lasting between 32 and 62 days (Prince William, 2004). The larvae can be dispersed miles along the coast, causing further distribution of this invasive species.

Invasive species, like the Green Crab, have considerable impact on their “new” habitats. For example, according to Macdonald et al. (2007), the arrival of “invasives” often leads to a decline in abundance and/or diversity of native species. They note that one possible reason is because of competition between the invasive species and the indigenous species, which have not previously dealt with such competition. The Green Crab in particular has been cited as having a strong influence on the abundance of bivalves due to predation (Grosholz and Ruiz 1994). Accordingly, Vermeij (1982) suggested that Green Crab predation has been a selective force in the evolution of *Nucella lapillus* shell size and shape. Further, Trussell et al. (2004) identified the existence of a trophic cascade where the Green Crab has effect on herbivorous snails, which in turn affect algal abundance, ultimately changing the structure of the entire community.

The invasion of the Green Crab has been causing structural changes in sub-tidal communities since their arrival in the US due to its predatory habits and ability to withstand a broad range of habitats and living conditions (Grosholz & Ruiz, 1994). However a recent invasion of a new crab species, the Asian Shore Crab (*Hemigrapsus sanguineus*) may threaten the Green Crab’s status as top predator. Arriving in the United States in1988, the Asian Shore Crab is an invasive species from the western Pacific Ocean (Griffen & Delaney, 2007). Smaller than the Green crab, adult carapaces grow to between 35 and 42mm in width. The *H. sanguineus* shell is more square-shaped than *C. maenas*, and has 3 spines instead of five. Coloring ranges from green to purple, to orange, brown or red and they have distinctive light and dark bands along the legs and red spots on the chelae (Benson, 2012) (Fig. 2).

Fig. 2: Asian Shore Crab (right) and Green Crab (left) in small sampling bucket

The Green Crab and Asian Shore Crab are now occupying the same habitats and praying on many of the same species. There are numerous studies comparing the two crabs in terms of niche partitioning to better understand this competitive interaction (Griffen & Delaney, 2007; Jensen et al., 2002; MacDonald, 2007), but there is no conclusive evidence as to which crab will be “better” at attaining the available resources.

The current study seeks to compare *Carcinus maenas*, the Green Crab, with the more recent invader, *Hemigrapsus sanguineus*, the Asian Shore Crab. As a demographic approach, data were collected on population size, sex, autotomy, and carapace size for each species.

Materials and Methods:

Green and Asian Shore crabs were collected at Nahant Beach, MA (44.45° N, 70.94° W). Sampling occurred at low tide in the mid to lower intertidal zones on two occasions – once in September and once in October of 2012 (Fig. 3). Collected haphazardly and by hand, crabs were found in tide pools and under rocks or algae. Students from a Marine Biology class aided sampling by collecting crabs as they came across them in their own exploration of the region. Two small buckets (approximately 1 quart each) were used to collect and transport crabs back to two larger buckets (5 gallons each) where crabs were held and later sorted for measurement (Fig. 4). Crab species and sex were recorded, followed by which, if any, legs were missing, and then the crabs were measured for width (across carapace left to right) and for length (anterior to posterior) using electronic calipers (Fig. 5). Crabs under 10mm in width were discarded to account for a potential sampling bias such that smaller crabs are harder to see and capture, and were therefore discounted from analysis altogether. An IPhone 4s was used to take all pictures.

Fig. 3: Nahant Beach: the rocky intertidal sampling site

Fig. 4: One Green Crab sits among the Asian Shore Crabs in a large collection bucket.

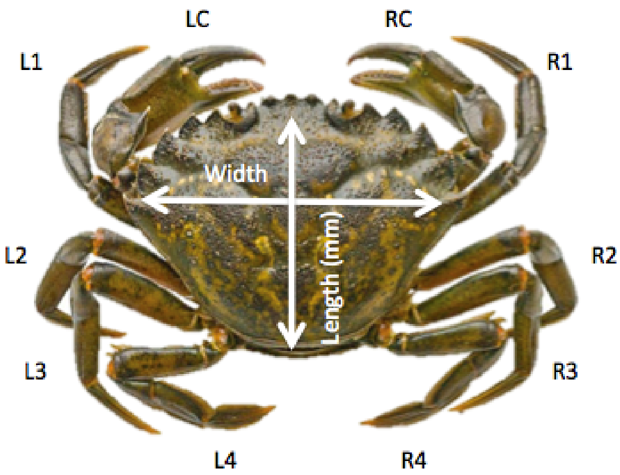

Fig. 5: Scoring scheme for crab legs, width, and length. Image of Green Crab from the Oregon Department of Fish and Wildlife

Results and Discussion:

A total of 155 crabs over 10mm in width were collected. There were 25 Green Crabs (4 female and 21 male) and 130 Asian Shore Crabs (81 female and 49 male). This data opposes data collected from a previous demographic study of crabs at Nahant by Clancy (2006). In their collected sample, Green Crabs population size almost doubled that of the Asian Shore Crab (11 to 6). These results show growth in the Asian Shore Crab perhaps indicating their successful habitat acquisition over the Green Crab.

Current data were analyzed with JMP Statistical Discovery software from SAS. There were significantly more male than female Green Crabs in our collected samples (p>.0001) (Fig. 6). There were also significantly more female than male Asian Shore Crabs collected (p>.0001). Sampling location within the intertidal may have affected these numbers.

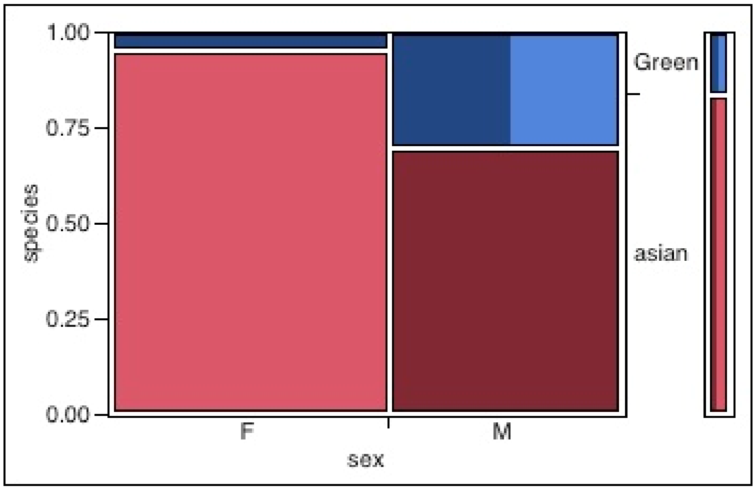

Fig. 6: Contingency Analysis of crab species by sex

Crab autotomy was also recorded. Autotomy is the ability for an organism to detach a part of their body in response to stress, increasing the likelihood of survival in dangerous situations (Davis et al., 2005). For crabs, this means the detachment of a walking leg or cheliped. Autotomy has effects on crab survival such that it may increase level of survival at first, but organisms with many autotomized limbs are likely to suffer long-term disadvantages such as slower feeding rate and lower fecundity (Davis et al., 2005). Autotomy was compared to crab width in a bivariate fit y by x analysis. Results showed a significant interaction between limb loss and width in the Asian Shore Crab population, such that as crabs got wider, they lost more limbs (p>.0001) (Fig. 7). Limb loss and width was also positively correlated for Green Crabs, but results were not significant. Currently, we are unsure whether the higher levels of autotomy in the Asian Shore Crab population are advantageous in the interspecies competition with Green Crabs or whether the lower levels of autotomy in the Green Crab population are advantageous.

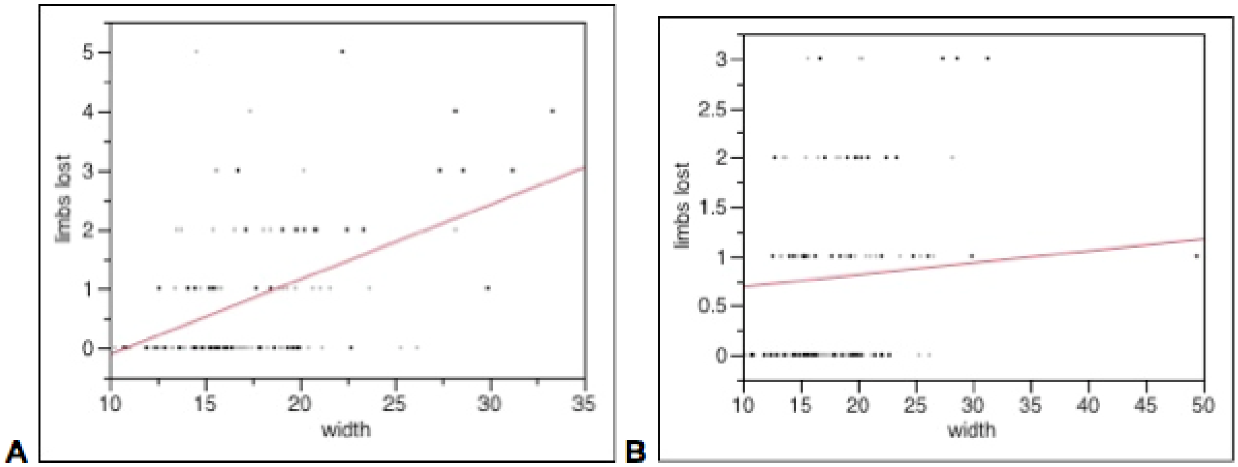

Fig. 7: Bivariate fit of autotomy by width per crab species, A is Asian Shore Crab and B is Green Crab

Using width data, crab size distributions over the entire population were analyzed to look for potential age classes. Crabs under 10mm were included in this analysis in order to get a complete understanding of the population (these crabs however were still omitted from mean and standard deviation analysis). In a distribution analysis, there appear to be four major age classes based on carapace width (mm) in intervals of 2.5. Clusters appear in the less than10mm category and at: 12.5-15mm, 20-22.5mm,and 47.5-50mm (mean=19.17, std. err. mean=1.6), with the most crabs falling below 10mm.

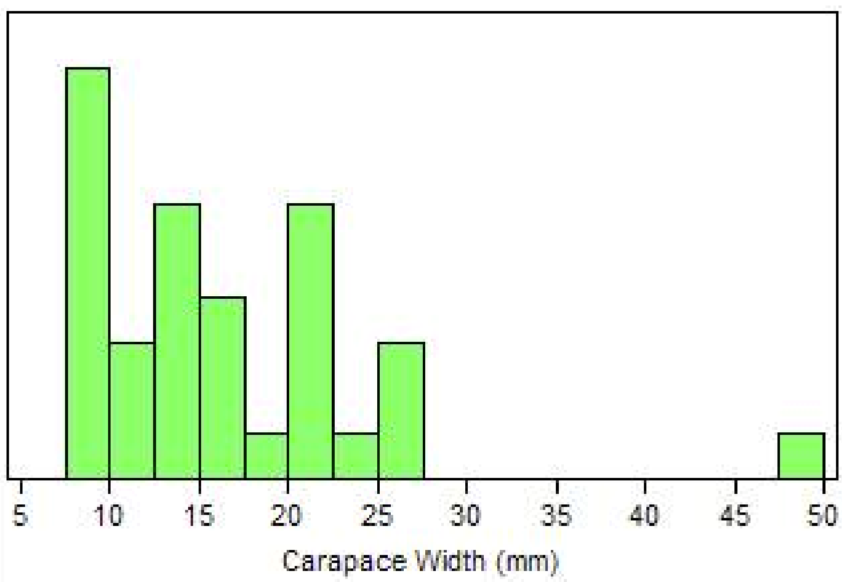

Fig. 8: Distribution of width across Green Crab population

Conclusion:

Comparing demographic data between *Carcinus meanas* and *Hemigrapsus sanguineus* is important to help understand the rocky intertidal ecosystem. If competition really exists between these crabs, it is likely that we will see changes in the numbers, size, and frequencies of the crab populations over time. Based on one study, it would appear as though the Green Crab has already lost is population size advantage over the Asian Shore Crab (Clancy, 2006). The data from the current study can be used in further investigations of niche partitioning between these shore crabs. Experimental work in the future could even position these crab species directly against each other in lab to investigate whether autotomy affects competition.

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