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Prey selection by Gulf of Maine green crabs (*Carcinus maenas*), rock crabs (*Cancer irroratus*) and American lobsters (*Homarus americanus*): A laboratory study

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ABSTRACT

Young green crabs (*Carcinus maenas*), rock crabs (*Cancer irroratus*) and American lobsters (*Homarus americanus*) co-exist in close proximity and forage on similar prey species in the rocky intertidal in the Gulf of Maine. Young green crabs (25–35 mm carapace width), rock crabs (25–35 mm carapace width) and American lobsters (25–35 mm carapace length) were collected along with the prey species blue mussels (*Mytilus* sp.), rock barnacles (*Semibalanus balanoides*) and common southern kelp (*Saccharina latissima*) from the rocky intertidal of the southern section of Saco Bay in the Gulf of Maine. Claw measurements were taken, prey size and prey species preference was tested and caloric value of prey was determined. Morphological measurements indicated that all three decapod species had different sized chela relative to body size. In the laboratory, the three predators preferred similar sized mussels and barnacles, and had similar handling times for both of these prey species. None of the three predator species consumed measurable amounts of kelp. Rock crabs and lobsters preferentially selected mussels over barnacles, while green crabs consumed equal amounts of both prey species. The preferred mussel size was smaller than the calculated optimum while the optimal barnacle size was eaten. These results suggest that while green crabs, rock crabs and lobsters have differing claw morphologies, they select similar prey and consume prey at the same rate.

1. Introduction

Prey selection has been investigated in many species and habitats to better understand ecological concepts such as niche partitioning (Leibold, 1995; Patten and Auble, 1981), optimal foraging (Pyke, 1984; Rapport, 1980; Schluter, 1981), and interspecific competition (Schoener, 1982; Tilman, 1987). An environment that has been extensively studied is the rocky intertidal due to its diverse and complex ecosystem (Lewis, 1964). The dynamics between predator and prey in this habitat have provided a wealth of insights into the ecological interactions of many species (see review by Underwood, 2000). Some of the more abundant and noticeable benthic predators in this habitat are decapod crustaceans (Ojeda and Dearborn, 1990). This group of predators may disproportionately shape the ecology of this habitat via top-down control (Menge, 1983; Tyrrell et al., 2006).

There have been a wide range of studies concerning the ecology of American lobsters (*Homarus americanus*), rock crabs (*Cancer irroratus*) and green crabs (*Carcinus maenas*) (Grosholz and Ruiz, 1996a, 1996b; Jones and Shulman, 2008; Menge, 1983; Ojeda and Dearborn, 1991; Reilly and Saila, 1978). However, research regarding foraging habits of young (animals that are either immature or just becoming reproductively active) of these species has been largely ignored. All three species have been shown to utilize areas of the Gulf of Maine as a nursery for their young (Berrill, 1982; Palma et al., 1999), with some of them remaining in the nursery habitat for several years (Berrill, 1982; Cowan et al., 2001). Larvae from both the American lobster and rock crab have been found to settle and mature on cobble substrate in close proximity to one another (Palma et al., 1999). Sub-adult American lobsters and green crabs were regularly observed within one to two meters of each other in Passamaquoddy Bay, Canada (Lynch and Rochette, 2009). Also, young of all three species have been collected from an area around Biddeford Pool, Maine on cobble substrate in wave exposed rocky shore line (Brown, unpub. data). Diet studies have shown that American lobsters, rock crabs and green crabs in various areas utilize a wide range of food resources (Ojeda and Dearborn, 1991; Stehlik, 1993; Sainte-Marie and Chabot, 2002; Brown, unpub. data). When examining stomach contents of young lobsters (17–45 mm cl, n = 65), green crabs (7–47 mm cw, n = 54) and rock crabs (14–44 mm cw, n = 67) in the current study area during June, August, and October of 2006, three categories that made up the largest portion of each species' stomach volume were barnacles (*Balanus* sp.) (40%), mussels (*Mytilus* sp.) (30%) and brown algae (20%) (Brown, unpub. data). These three prey items have been observed being preyed

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Table 1
Crab and lobster size [carapace width (cw) for crabs, carapace length (cl) for lobsters and weights for all] range, average and standard deviation for all specimens used in the three parts of this study. Weights were not recorded for the crabs and lobsters used in the prey size selection experiment. The crabs and lobsters used for prey species selection were a subset of the claw morphology animals.

Predator species	Cw or cl range (mm)	Average cw or cl (mm)	Cw or cl SD	Weight range (g)	Average weight (g)	Weight SD	n
Crabs and lobsters used for prey size selection							
Green crab	25.45–34.85	29.51	2.55	NA	NA	NA	39
Rock crab	25.20–34.65	29.85	2.89	NA	NA	NA	34
American lobster	25.10–34.55	29.95	2.61	NA	NA	NA	36
Crabs and lobsters used for claw morphology							
Green crab	26.40–61.58	32.94	6.58	4.24–46.2	8.99	7.27	46
Rock crab	19.23–63.65	33.55	8.33	1.16–38.26	7.30	6.24	70
American lobster	20.29–53.17	34.96	7.90	6.07–121.39	39.39	29.19	51
Crabs and lobsters used for prey species selection							
Green crab	26.40–35.00	30.91	2.57	4.24–9.64	6.83	1.58	40
Rock crab	25.82–34.9	30.62	2.84	3.20–7.95	4.79	1.26	39
American lobster	25.56–34.68	30.29	2.83	13.02–35.54	22.18	7.14	22

upon and found in the stomachs of all three predator species both in the Gulf of Maine and elsewhere (Baeta et al., 2006; Ojeda and Dearborn, 1991; Rangeley and Thomas, 1987; Sainte-Marie and Chabot, 2002; Stehlik, 1993; Tyrrell et al., 2006), indicating that similar prey is being consumed regularly by the young of all three decapods species. However, it is still unknown if a preference for a particular size group or prey species exists for each decapod predator.

Consumption of the same prey species does not necessarily infer direct competition. The ability to utilize prey resources may vary among these three decapods causing either an increase or decrease in interspecific competition. There are morphological differences among adults of each species that may account for resource partitioning between these decapods. Moody and Steneck's (1993) findings suggest a functional dichotomy exists among the adults of each of the three species. The lower dexterity of the American lobster compared to the crabs, coupled with differing claw morphologies creates contrasting foraging tactics when they are presented with mussels. Lobsters are restricted to crushing, while both crab species can crush, chip and pry open mussels. These differences allowed for the rock and green crabs to successfully attack larger mussels and have shorter handling times than the lobsters by utilizing complex attack methods. The two crab species also differ from one another in regards to their chelae. Rock crabs have slightly smaller claws relative to body size than green crabs (Vermeij, 1977), which could have an effect on prey choice. Additionally, factors such as prey density/availability (Holling, 1959; Solomon, 1949), habitat (Sponaugle and Lawton, 1990) and the presence of predators affect predation behavior (Siddon and Witman, 2004).

The present evidence suggests that young American lobsters, young rock crabs and young green crabs inhabit the rocky intertidal and sub tidal, prey upon mussels, barnacles, algae and other food items. Young crabs (25–35 mm cw) and lobsters (25–35 cl) are very abundant in the mid to low intertidal in Saco Bay, Maine and all three species can be found within a meter of each other (personal observation). Although crabs and lobsters differ in age and mass at this size range, ecologically this is an important life stage for all three species. Young lobsters begin to actively forage outside of their shelters (see review by Lawton and Lavalli, 1995) and crabs are just becoming sexually mature (Crothers, 1967; Reilly and Saila, 1978). The effect of the invasive green crab on the local ecology and their prey preferences also requires more investigation to determine their impact on the ecosystem (Breen and Metaxas, 2008; Eastwood et al., 2007; Grosholz and Ruiz, 1996a, 1996b). Additionally prey preference can further understanding of ecological theories and give insight into the life of the commercially valuable lobster (Anonymous, 2009).

This study addressed whether prey preferences occur among these three decapod predators. This was done in the laboratory by presenting each crab species and lobster with the non-motile prey items predominantly found in the predator's stomachs in the study area by Brown (unpubl. data). Mussels, barnacles and kelp were presented in a range of sizes to determine preference for prey size. Then, all three prey items of the preferred size were simultaneously presented to test for prey species preference. Finally, claw morphology and caloric content of prey were used to further compare prey utilization of young American lobster, rock crabs and green crabs.

2. Methods

2.1. Specimen collection and maintenance

2.1.1. Predators

Young American lobsters (*Homarus americanus*), green crabs (*Carcinus maenas*) and rock crabs (*Cancer irroratus*) were collected on cobble substrate by hand in the intertidal zone near Biddeford Pool, Maine (43°26′32.42″N, 70°20′28.34″W), and via suction sampling (near Wood Island, Maine (43°27′17.68″N, 70°20′6.62″W) in approximately 6 meters of water; Table 1). Only animals that were undamaged (all appendages fully regenerated) and hard shelled were used in this study. All specimens were housed in individual holding containers constructed out of 7.6 cm diameter PVC pipe for crabs and 10.2 cm diameter PVC pipe for lobsters. The containers were soaked in sea water for one day prior to use, in the flow through sea water system in the Marine Science Center (MSC) at the University of New England (UNE). The rate of water flow was approximately 83 ml/sec. The water temperature in the system ranged from 9.7 °C to 26.8 °C during the six and seven month testing periods, in 2007 and 2008 respectively, with an average temperature of 16.5 °C. Salinity ranged from 28.7 ppt to 35 ppt with 29.6 ppt being the average. Due to these fluctuations in environmental conditions tests were conducted to determine correlation with predator behavior. The three species were maintained in separate 72 cm × 180 cm seawater trays to prevent any possible interspecific chemical cues from affecting behavior. All crabs and lobsters were exposed to a lighting regime reflective of the local natural light:dark cycle (10–14 h of light) by exposure to white light via a 60 watt clear light bulb during the day and a 25 watt red light bulb during the night. All three species were fed chopped fish until satiated the day after they were collected from the field to standardize last meal. Then food was withheld for five days, after which prey preference testing was performed.

2.1.2. Prey

Mussels (*Mytilus* sp.), rock barnacles (*Semibalanus balanoides*) and common southern kelp (*Saccharina latissima*) were collected by hand from the same areas as the predator species. Mussels were maintained in flowing sea water separate from the predators at UNE until they