Predators of Juvenile Blue Crabs Outside of Refuge Habitats in Lower Chesapeake Bay

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ABSTRACT: Blue crabs Callinectes sapidus in lower Chesapeake Bay are subject to high rates of predation during the late summer of their first year of growth as they migrate out of vegetated nursery habitats. Predators, potentially contributing to this pattern, were identified in video-recorded field observations of tethered juvenile crabs (20–25 mm carapace width). Predators were also tested in large laboratory tanks containing similarly-sized untethered crabs as prey. Seven different predators attacked tethered crabs in the field. Only two predators, larger blue crabs and northern puffers, Sphoeroides maculatus, consistently succeeded in preying on crabs in both field and laboratory settings. These results confirm the importance of cannibalism on juvenile blue crabs and identify puffers as a potentially overlooked source of predation pressure.

Introduction

Population dynamics of blue crabs, Callinectes sapidus (Rathbun), in Chesapeake Bay suggest that predator-induced mortality of early benthic juveniles may play a role in determining the year-class strength of this species (Hines et al. 1987; Lipcius and Van Engel 1990). The vagile nature of blue crabs and the low visibility common in shallow estuarine habitats make it difficult for predators of free-ranging blue crabs to be observed and described in this system. Most information about predators of blue crabs comes from gut-content analyses of demersal fishes (Manooch 1973; Bass and Avault 1975; Overstreet and Heard 1978; Hines et al. 1990). Studies of adult blue crab diets and intraspecific interactions have indicated that cannibalism may also represent a major component of the predation pressure on juvenile crabs (Hines et al. 1990; Hines and Ruiz 1995; Moksnes et al. 1997). While gut contents clearly provide dietary information, they may not reliably represent mortality, because many types of indicator fragments may be the result of partial predation (Juanes and Smith 1995), scavenging, or consumption of molted exoskeletal components (Hyslop 1980; Williams 1981). Direct observations of predation events may provide a more reliable and comprehensive view of patterns of predation on blue crabs.

In the lower reaches of Chesapeake Bay, blue crab larvae recruit to shallow, protected areas, such as seagrass beds or tidal creek root mats, and begin the benthic juvenile phase of their life history during the late summer and early fall (Heck and Thomas 1984; Orth and van Montfrans 1987). Population studies in these areas suggest that as juvenile crabs grow, they undertake an ontogenetic habitat shift out of refuge habitats and into surrounding unvegetated areas (Pile et al. 1996; Pardieck et al. 1999). This shift has been associated with a size-mediated reduction in predation pressure. Other evidence suggests that structured environments may continue to be important to larger crabs as movement corridors (Micheli and Peterson 1999) and for refuge during molt cycles (Ryer et al. 1997). In a study of predation on juvenile blue crabs in the lower York River estuary in Chesapeake Bay, it was determined that mortality rates of crabs tethered in unvegetated habitats were greater than in vegetation for all size classes, and that predation pressure in both habitats varied seasonally, peaking in July and August (Moody 2001). Experiments in a sub-estuary of the central portion of the Bay produced similar results (Hines and Ruiz 1995). If these patterns are seasonally consistent, then the months of July and August during the first year of growth could represent the period of highest predation pressure throughout the entire benthic phase of the life history of blue crabs in Chesapeake Bay, especially for crabs making the transition out of refuge habitats.

Here I describe video-recorded observations undertaken to identify and characterize predators of juvenile blue crabs in shallow unvegetated areas in late summer at the mouth of the York River estuary in Chesapeake Bay. This project combined field
studies of predation on tethered crabs and laboratory studies of predation on untethered crabs in an effort to compensate for potential artifacts in both. The objectives for this project were mainly exploratory, but the data were collected in a manner that allowed comparisons to be made among the predators with respect to their likelihood of preying on free-ranging crabs.

Materials and Methods

Field Observations

Predators of juvenile blue crabs in shallow water habitats were identified by using an underwater video recording system to monitor tethered crabs. The system consisted of a camera head connected by a 12-m cable to an 8 mm video recording unit. The camera head was sealed in a small underwater housing (18 × 10 × 6 cm) that was painted gray to reduce visual contrast, and deployed at a depth of approximately 1 m in unvegetated areas along both shores of the mouth of the York River estuary (76°18′N, 37°9′W). All crabs were tethered at least 3 m from the nearest vegetation (typically Zostera marina, Linnaeus) and at least 10 m from any other deployment site. Other nearby habitats that were not examined included more exposed sandy flats and muddier tidal creeks.

Forty-nine 2-h sequences were recorded during the months of July, August, and September in 1991 and 1992. All recordings were made between the hours of 0900 and 1300 during high tide conditions, as this condition offered the most consistent visibility. Prior to each recorded sequence, a locally-collected crab measuring between 20 and 25 mm in carapace width (CW; from the tips of the lateral spines) was tethered to a short aluminum stake that was pushed into the sediment 30 cm in front of the camera head. The tethers (approximately 20 cm long) were made of light steel fishing leader material looped around the spines of the carapace and closed with a metal crimping band. The tether material was flexible enough to allow the crabs to move, but rigid enough to preclude tangling. There were no instances observed of crabs escaping from their tethers during the experiments. The recording unit was monitored from a small boat, anchored approximately 10 m from the camera head. In cases where a tethered crab was killed during a 2-h sequence, the camera head was moved to a new location and the crab was replaced with a live specimen for the remainder of the sequence. The choice of size range for the crabs observed (20–25 mm CW) was based on two factors. The size distribution of juvenile crabs from the study area in August 1990 (before the seasonal recruitment) showed a strong mode at 20 mm (Lipcius et al. In press). Initial tests with the underwater video system indicated that tethered crabs smaller than 20 mm could not be reliably observed while maintaining a wide enough field of view to identify predator species.

To avoid counting the same individual predator multiple times, each 2-h sequence was treated as an event field, and categorized relative to each potential predator species as containing at least one appearance, containing at least one attack, and containing a successful attack (resulting in the death of the tethered crab). The results were expressed and analyzed as rates or proportions of the total number of event fields recorded (49). Two additional values were calculated for each predator species to more fully characterize behavioral differences; the relative attack rate (the proportion of appearance-containing sequences that also contained at least one attack) and the relative success rate (the proportion of attack-containing sequences that also contained a successful attack). The purpose for calculating these additional rates was to represent the motivation and effectiveness of the predator species identified.

Laboratory Observations

Tethered blue crabs in the field experiments were not prevented from exhibiting defensive behaviors such as burying, fighting, running, or swimming short distances. Their ability to evade predators was severely limited relative to untethered individuals, resulting in inflated predator-induced mortality rates (Zimmer-Faust et al. 1994). For this reason, the relative effectiveness of the predators identified in the field experiments was re-examined in large (approximately 2 × 4 × 1.5 m deep) laboratory tanks, containing sediment and unfiltered water from the York River estuary. Although the ability of crabs to avoid predators was still restricted in these tanks, the untethered crabs were able to run, swim, bury, and defend themselves along the tank wall in a much more natural manner. Each trial involved exposure of 10 untethered juvenile crabs (approximately 20 mm CW) to a single adult predator for 6 h (starting at sunrise) in the experimental tank. The predators were collected with an otter trawl near the tethering sites, and each individual was held in isolation in the laboratory for approximately 48 h prior to being placed in the experimental tank. Sizes of predators varied, but all were larger than size at maturity according to the U.S. National Marine Fisheries Service statistics. No individual predator or crab prey specimens were used for more than one trial, and the water in each tank was drained and replaced between trials. A total of 28 trials were performed, including at least 3 for each of the 7 predator spe-