Tethering as a Technique for Assessing Predation Rates in Different Habitats: An Evaluation using Juvenile Lobsters *Homarus americanus*

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Tethering has been used successfully to assess predation rates of a variety of predator-prey systems in several different habitats. The majority of these experiments have used tethered crabs as prey (Heck and Thoman 1981, Wilson 1985, Wilson et al. 1987, Heck and Wilson 1988, Wilson et. al. 1990, Barshaw and Able In press). Fish have also been tethered in different habitats; however, in these experiments the tethered fish could not act naturally, and therefore the technique only showed the differences in predator encounter rate in different habitats (Shulman 1985, McIvor and Odum 1988). Other organisms are presently being used in tethering experiments including molluscs (R.N. Lipcius and L.S. Marshall, Jr., Coll. William and Mary, Va. Inst. Mar. Sci., Gloucester Pt., VA 23062, unpubl. data) and spiny lobsters (Herrnkind and Butler 1986).

We determined if tethering was an appropriate technique to assess predation on species that burrow (i.e., juvenile lobsters *Homarus americanus*). Lobsters were chosen for this study, in part, because their behavior has been well studied and, therefore, a baseline of "normal" behaviors is available (Botero and Atema 1982, Barshaw and Bryant-Rich 1988).

Lobsters use different methods of constructing burrows in different habitats; therefore we tested three habitats known to be important for early juvenile lobsters: mud, cobble, and *Spartina* peat (Able et al. 1988, Barshaw and Lavalli 1988).

Methods and materials

Six "ant farm" aquaria (10 cm wide, 30 cm long, 45 cm deep) were 2/3 filled with either cohesive mud, cobble of a natural size distribution, or *Spartina* peat substrates (two replicates per substrate type) and provided with running, unfiltered seawater. Early juvenile lobsters (8–14 mm carapace length) were individually tethered to monofilament line using "super glue" to attach it to their carapace. Individual tethered lobsters were placed into half the tanks while similar-sized untethered control lobsters were placed into the remaining tanks.

A discrete reading of each lobster's behavior was recorded every minute for the first 20 minutes, every 5 minutes for the next 35 minutes, and then every hour for 6 hours. A final assessment of each lobster's burrow was made after 24 hours. Therefore, each lobster was observed 33 times over 24 hours in each test. Seven tests were run using all the substrates, with two extra tests run only with mud; thus observations were made on a total of 14 lobsters in cobble, 14 in peat, and 26 in mud. The behaviors observed are described in Table 1.

The behaviors of the tethered and untethered lobsters were compared by calculating the percent of the 33 observations in which the lobsters were engaged in each of the behaviors for each test. Since this experiment was designed only to compare tethered and untethered lobsters, no comparisons were made between different behaviors or between different substrates (comparisons of that nature were studied in Barshaw and Bryant-Rich 1988). The percent of observations was transformed using the arc-sign transformation, and analyzed with a Student's t test. The numbers of the tethered and untethered lobsters that had burrows at the end of the experiment were analyzed for each substrate using 2×2 contingency tables and chi-square tests.

Results

The tethering of juvenile lobsters resulted in substrate-specific differences in behavior and the ability to construct burrows. There were no significant differences between the behavior of tethered and untethered lobsters in the peat or cobble substrates (Fig. 1); in both peat and cobble, all the tethered (7/7) and all the untethered (7/7) lobsters had burrows that they constructed and maintained throughout the experiment.

Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

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Table 1
Description of behaviors of tethered and untethered juvenile *Homarus americanus* observed in this experiment.

Behavior	Description
Rest (RST)	No movement for at least 30 seconds. Grooming was not considered movement and was not recorded separately from RST.
Pleopod fan (PPF)	Movement of the pleopods which caused sediment to be moved; i.e., was being used to build or repair the burrow. In this study PPF which only moved water was not recorded.
Bulldoze (BLD)	Pushing sediment forward with the claws and first walking legs spread apart.
Dig	Loosening sediment by pushing claws into it.
Walk (WLK)	Walking on the sediment; does not include "walking" in the burrow.
Swim	Swimming in the water column.

In the mud substrate, however, the tethered lobsters walked significantly more and bulldozed significantly less than the untethered lobsters (*t* test, $p<0.05$, Fig. 1). (There was a trend in the tethered lobsters to bulldoze less in all of the substrates). Also, in the mud substrate most tethered lobsters were unable to make or maintain a burrow. Only 7.7% (2/13) of the lobsters had constructed a complete burrow, deep enough to hide the lobster at the end of the 24-hour period. This result was significantly different from the untethered group in which 69.2% (9/13) had constructed burrows by the end of the experiment (chi-square test, $p<0.05$).

Discussion

These observations demonstrate a substrate-specific difference in the effect of tethering on the burrowing behavior of juvenile lobsters. While tethering did not substantially effect the behavior or burrow construction of lobsters in peat or cobble, lobsters tethered in mud spent more time walking, less time bulldozing, and were unable to build and maintain a burrow as well as the untethered lobsters. The tethered lobsters in mud would therefore be more vulnerable to predation than the untethered controls, since being without a burrow has been demonstrated to increase mortality due to predation (Barshaw and Lavalli 1988). Heck and Thoman (1981), Heck and Wilson (1988), and Barshaw and Able (In press) conducted predator-prey experiments using tethered crabs as the prey. *Neopanopi sayi*, *Panopeus herbsti*, *Libinia dubia*, *Ovalipes ocellatus*, and *Callinectes sapidus* were tethered using similar techniques as were used in our study. These investi-

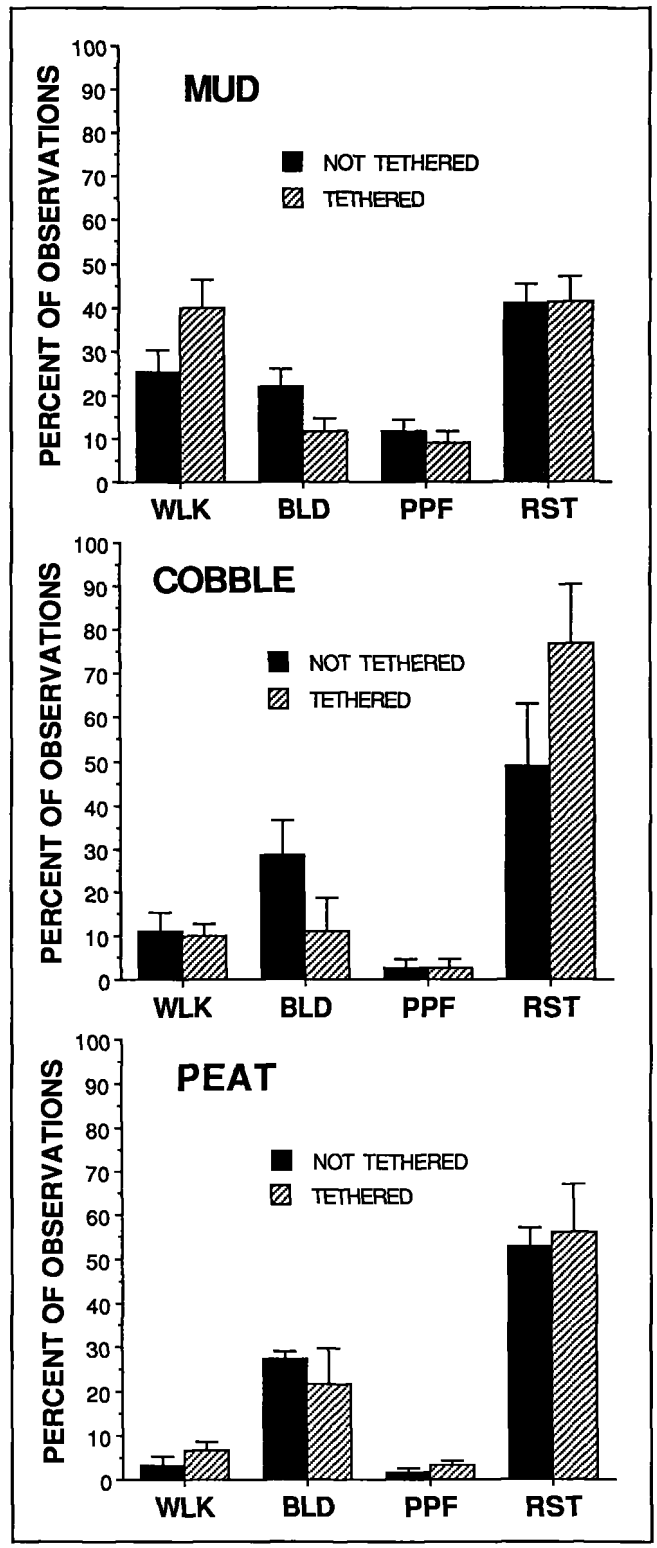

Figure 1
Average percent of the 33 observations in which lobsters were observed doing each behavior in each substrate. WLK = walk, BLD = bulldoze, PPF = pleopod fan, RST = rest.

gators did not observe any differences in the behavior of crabs tethered in different substrates. The differences in tethering effects between these investigations and ours are probably due to the fact that *Homarus americanus* construct burrows in the substrate while the crabs used in the above tethering experiments simply bury themselves directly into the substrate.

The results of this study suggest that tethering to assess predation in different habitats should be evaluated for each new species under consideration because species-specific behavior patterns could create habitat-specific tethering artifacts. In particular, caution should be used when interpreting survival rates of lobsters in mud relative to other substrates. Similar caution should be considered when tethering is used to assess predation in other burrowing forms.

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