A POSSIBLE EXPERIMENTAL ARTEFACT ASSOCIATED WITH LEAF TETHERING IN CRAB HERBIVORY STUDIES.

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Abstract

The rate at which crabs consume leaves and propagules in mangrove forests is often measured by tethering the leaves or propagules to the forest floor using a lengths of nylon fishing line. This technique was used to estimate rates of crab consumption of leaves of *Avicennia marina* in two temperate mangrove forests near Sydney, Australia. Rates of herbivory were low compared to those in tropical forests. An experimental artifact was identified, in that unbaited lines were also found trailing down burrows, suggesting that tethers may be inadvertently intercepted by crabs.
Keywords: mangrove, crab, herbivory, tethering, burrows.

Introduction

A number of recent studies have sought to use tethering experiments to establish the extent of herbivory by crabs on mangrove leaf litter (Robertson, 1986; Camilleri 1989; Robertson & Daniel, 1989; Smith & Daniel, 1989; Micheli, 1993; Steinke *et al.*, 1993) and mangrove propagules (Smith, 1987a,b; Osborne & Smith 1990; Smith *et al.*, 1989; McKee, 1995; McGuinness, 1997a, b). These studies generally describe high rates of herbivory on mangrove leaves and propagules in tropical environments.

However, the use of tethering introduces the possibility of experimental artefacts because the tether may alter the predator's capacity to capture and consume the prey (Barshaw & Able, 1990; Peterson & Black, 1994; Aronson & Heck, 1995). McGuinness (1997c) considered the possibility that tethers restrict the capacity of crabs to remove propagules, and experimentally demonstrated that while short tether lengths might lead to an underestimation of predation rates, the technique would not invalidate comparisons between habitats.

A second experimental artefact could be that tethering may increase the frequency with which crabs take leaves and propagules, in that crabs may intercept the tether, either intentionally or passively. Robertson (1986) and Smith (1987a) used controls of unbaited line to test for this artefact. Both studies found no unbaited lines within burrows. They concluded that the frequency with which baited lines were found within burrows represented the rate at which crabs selected and consumed leaves or propagules.

The aim of the present study was to determine whether rates of crab herbivory on mangrove leaves in temperate environments could be estimated using tethering, and in particular to determine whether the tether acted to increase apparent rates of leaf selection. Two sites were chosen in order to test the assumption that the degree of experimental artefact would not vary between locations.

Materials and Methods

Crab herbivory was studied at two estuarine intertidal sites 13 km from the coast in temperate Australia. Jerusalem Bay (151°12' E, 33°35'S), is a sandy tributary within Broken Bay, immediately to the north of Sydney. *Heloecius cordiformis* was the only crab encountered. Gungah Bay (151°08' E 33°58'S), is a tributary delta of the Georges River to the south of Sydney consisting of silty muds derived from a shale catchment. *Heloecius cordiformis* was again the dominant species, though *Sesarma erythrodactyla* was also common.

Twenty-six quadrats were established during the height of summer at each of the two sites, all quadrats being 4 by 4 metre squares of nylon string. Eight one metre lengths of monofilament line were tied at the perimeter of the quadrats. Quadrats were randomly distributed at the seaward edge of the forests, where burrow densities were highest. Leaves of *Avicennia marina*, the dominant mangrove in both locations, were attached to the free end of the nylon twine in thirteen of the quadrats in each location. The lines in the other thirteen quadrats were left unbaited.

The length of line (one metre) and the duration of the experiment (two weeks), followed the methodology described in Smith (1987a), Robertson and Daniel (1989), Osborne and Smith (1990), and McKee (1995). Upon returning to the quadrats the number of lines leading into burrows were counted. Lines with mid-sections in burrows but the tips outside were not considered to be captured.

Results

Overall, unbaited lines were found down burrows with greater frequency than those baited with leaves. At Jerusalem Bay, 26 unbaited lines were found trailing into burrows, and at Gungah Bay 3 unbaited lines were found in burrows at the conclusion of the experiment. These results compare with only 5 baited lines at Jerusalem Bay and one baited line at Gungah Bay being found down a burrow after two weeks. In all, only 2.9% of the 208 leaves were found in burrows at the end of the experiment compared with 13.9% of the 208 lengths of unbaited monofilament.

Discussion

At both sites the percentage of leaves taken into burrows was less than five percent, a figure well below the estimate for tropical forests of 70-80% described by Robertson and Daniel (1989) for forests of *Ceriops tagal* and *Bruguiera exaristata*, and 33% for forests dominated by *Avicennia marina*. The high rates of consumption in the *Ceriops* and *Bruguiera* forests (Robertson & Daniel, 1989) were in the presence of crab communities dominated by sesarmid crabs, and lower rates of predation in the temperate communities may relate to lower numbers of sesarmids in the locations sampled. In all our observations to date, *Heloecius cordiformis* has only been seen feeding on flocculent detritus, whereas the major food item of sesarmid crabs is leaf litter (Malley, 1978; Nakasone *et al.* 1985), and partially dissected leaves were noticed at the entrance of sesarmid burrows in Gungah Bay.

In contrast to the findings of Smith (1987a), many of our unbaited lines were found trailing into crab burrows at the conclusion of the experiment. This observation highlights a potential experimental artefact; that crabs may be passively intercepting the tether rather than selecting the leaf. Indeed, a higher proportion of our unbaited lines were found within burrows than baited lines, which may indicate that the leaf acts to anchor the tether on the forest floor, reducing the likelihood line being captured in the burrow.

A number of observations lead us to conclude that tethers may be frequently intercepted by crabs crossing the intertidal flat, increasing the probability that they will be found in burrows at the conclusion of the experiment. In one instance a crab was observed inadvertently catching a tether as it moved into a burrow, taking the line with it, and on more than one occasion the lines were retrieved from burrows entangled in the legs of crabs. At Gungah Bay, where the line adhered to saturated muds, the frequency of unbaited line capture was lower.

The extent of this artefact is not consistent between sites, making comparisons between experiments problematic. Our experiment resulted in higher unbaited line capture at the Jerusalem Bay site, possibly reflecting differences in crab species or sediment characteristics, as described above. In comparison to Smith (1987a), who found no unbaited tethers down burrows at the conclusion of his experiment, the artefact appears more prevalent in temperate than tropical situations, possibly due to differences in crab species.

While tethering remains the most popular method for the estimation of herbivory rates, alternatives methods have been published, including gut content analysis (Camilleri 1992, Steinke *et al.* 1993), field experiments involving wire grids (Micheli *et al.* 1991) and laboratory simulation of the intertidal habitat in which consumption is measured directly (Giddins *et al.* 1986, Lee 1989, Camilleri 1992, Emmerson and McGuire 1992). These studies are consistent with the proposed high rates of herbivory in tropical systems, and may provide a useful model for further investigations of crab herbivory in the temperate environment.

Estimation of herbivory rates using tethering experiments should only be done in the presence of rigorous controls. Unless it can be demonstrated in an experiment that crabs do not passively intersect lines, promoting the likelihood of their capture in burrows, it is difficult to see how the accuracy of rates of herbivory thus determined can be accepted. If the aim of the experiment is to compare herbivory rates between environments, it must be demonstrated that any experimental artefact operates to a consistent degree in the different settings. The results from this experiment suggest that that may well not be the case.

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