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Trophic relationships on a fucoid shore in south-western Iceland as revealed by stable isotope analyses, laboratory experiments, field observations and gut analyses

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ABSTRACT

Rocky shores in the North Atlantic are known for their zonation patterns of both algae and animals, which can be expected to greatly affect food availability to consumers at different height levels on the shore. We tested the hypothesis that consumers would feed on the most abundant suitable food source in their surroundings. In total 36 species/taxa of common primary producers and consumers were sampled for stable isotope analyses from a sheltered fucoid shore at Hvassahraun in south-western Iceland. A selection of these species was also collected seasonally and from different height levels. Feeding experiments, field observations and gut analyses were also conducted. Our results were in good overall agreement with pre-existing knowledge of trophic relationships in the rocky intertidal. Consumers often appeared to be assimilating carbon and nitrogen from the most common diet in their immediate surroundings. The predator *Nucella lapillus* was thus feeding on different prey at different height levels in accordance with different densities of prey species. When tested in the laboratory, individuals taken from low on the shore would ignore the gastropod *Littorina obtusata*, uncommon at that height level, even when starved, while individuals from mid-shore readily ate the gastropod. This indicated that some kind of learned behaviour was involved. There were, however, important exceptions, most noteworthy the relatively small contribution to herbivores, both slow moving (the gastropod *L. obtusata*) and fast moving (the isopod *Idotea granulosa* and the amphipod *Gammarus obtusatus*) of the dominant alga at this site, *Ascophyllum nodosum*. The recent colonizer *Fucus serratus* seemed to be favoured. Selective feeding was indicated both by isotope signatures as well as by results of feeding experiments. Seasonal migrations of both slow and fast moving species could partly explain patterns observed.

1. Introduction

Rocky shores in the North Atlantic are typically covered with several fucoid species that form distinct zonation patterns (Lewis, 1964). Zonation patterns can be expected to affect food availability, especially to sessile and slow moving consumers, both primary consumers and predators, mostly confined to certain height levels. It is almost self-evident that consumers will choose prey types that will maximize their fitness (Stephens and Krebs, 1986). There are numerous ways in which this can be achieved. One way is to feed on dominant organisms in the immediate environment, thus saving energy when foraging. There are, however, obviously many factors that contribute to selective feeding, complicating the issue, e.g. danger of predation, contents of harmful chemical components and previous dietary experience.

Studies of trophic relationships are fundamental for understanding the functioning of ecosystems. Intertidal ecosystems around the world have been the focus of intensive research, both for scientific and economic reasons (e.g. review by Raffaelli and Hawkins, 1996). This has included studies of trophic relationships by various methods. In addition to more traditional methods, the use of stable isotope ratios has increased rapidly in recent years in a variety of coastal habitats (e.g. Bustamante and Branch, 1996; Dunton, 2001; Adin and Riera, 2003; Yokoyama and Ishihi, 2007), but including only a few studies at community level on fucoid shores (Dauby et al., 1998; Sarà et al., 2007). The use of stable isotopes can serve as a powerful tool showing what the organism has been assimilating over a long period. Interpretation of stable isotope values can, however, be complicated, due to variability in isotope ratios within species of primary producers and overlap between different species (Schwinghamer et al., 1983; Stephenson et al., 1984; Siemenstad et al., 1993). Previous $\delta^{15}N$ and $\delta^{13}C$ fractionations have shown rather similar changes in average values between a prey and its consumer, approximately +3.0‰ for $\delta^{15}N$ (e.g. DeNiro and Epstein, 1981) and +0.8‰ for $\delta^{13}C$ (e.g. DeNiro and Epstein, 1978). Fractionation values can, however, vary between species (e.g. Macko et al., 1982; Vanderklift and Ponsard, 2003). Due to

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this it is of essence to combine the use of stable isotopes with more traditional methods when studying trophic relationships in a community. A few studies have done this, including studies focusing on invertebrates in the marine environment (Créach et al., 1997; Laurand and Riera, 2006).

The main objective of the present study was to identify the trophic relationships in space and time of common species found on a fucoid shore in Iceland, focussing on invertebrates. We try to test the following hypothesis: Do consumers on a fucoid shore at Hvassahraun, south western Iceland, assimilate/eat the most abundant

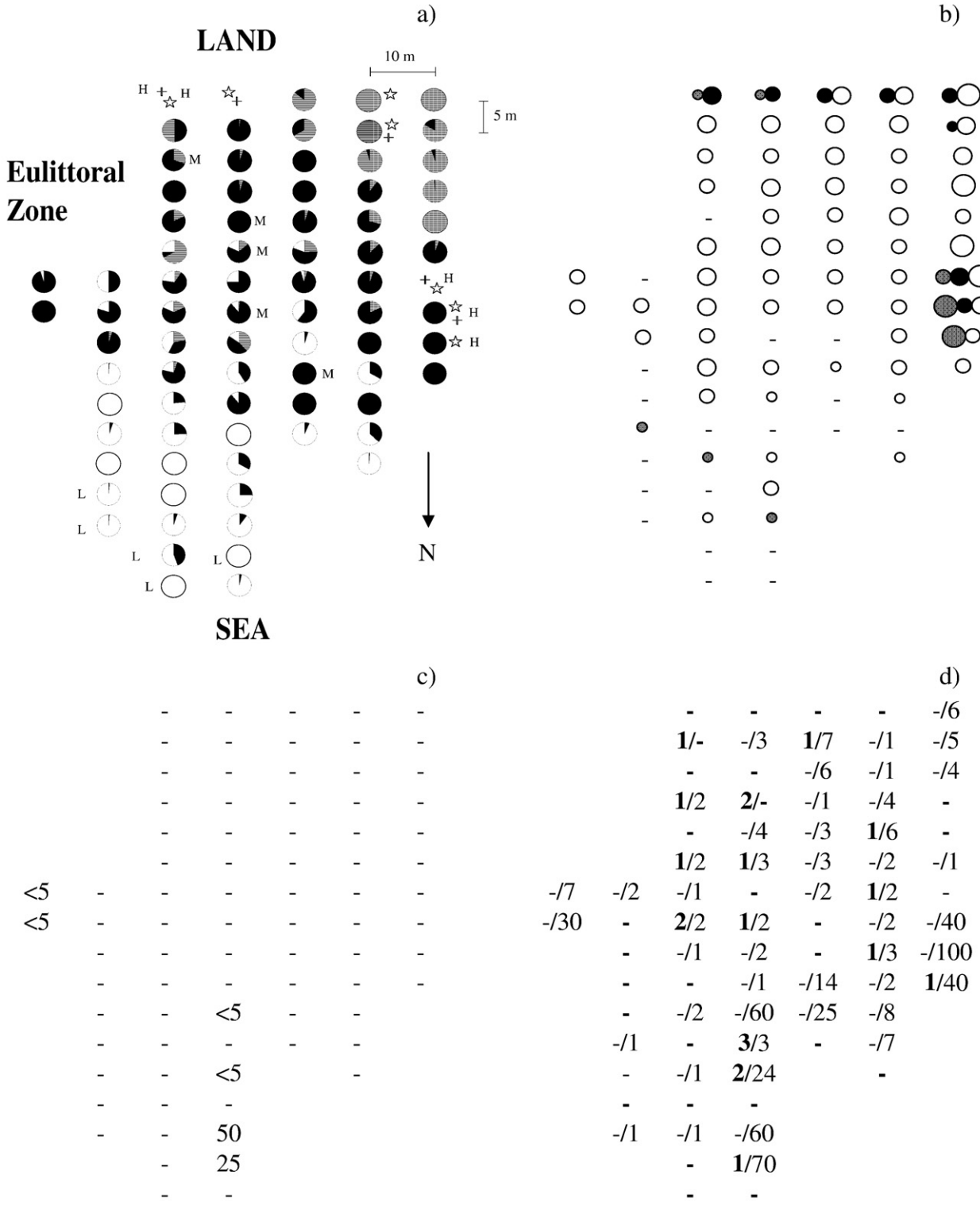

Fig. 1. Abundance of common rocky shore organisms on 80 frames in the eulittoral zone at Hvassahraun. A large lava outcrop explains the presence of high intertidal algal and animal species to the right on the figures. Dashes (−) indicate that the species were not found in that frame. a) Relative percentage cover of the 3 most common algal species, *Ascophyllum nodosum* (●), *Fucus serratus* (○) and *F. vesiculosus* (⊜). In addition, the presence of *Fucus spiralis* (☆) and *Pelvetia canaliculata* (+) is shown. Sampling locations are shown in the low (L), mid (M) and high (H) intertidal. b) Estimated abundance of *Littorina obtusata* (○), *L. saxatilis* (●) and *Semibalanus balanoides* (◍). The size of the circles indicates within-species relative abundance. c) Percentage cover of *Mytilus edulis*. d) Numbers of *Carcinus maenas* (before slash in bold numbers) and *Nucella lapillus* (after slash).