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Research Article

Effect of Ocean Acidification on the Communications among Invertebrates Mediated by Plant-Produced Volatile Organic Compounds

Abstract

Chemical communications among plant and animal components are fundamental elements for the functioning and the connectivity of ecosystems. In particular, wound-activated infochemicals trigger specific reactions of invertebrates according to evolutionary constraints, permitting them to identify prey cues, escape predators and optimize their behaviors according to specific life strategies. Thus, the correct flux of information made possible by the production of plant infochemicals and its recognition by given invertebrates is fundamental to assure an appropriate functioning of complex ecosystems. However, global warming and ocean acidification (OA) are deeply influencing the metabolism of organisms and confounding their chemical communications. The production of plant secondary metabolites is influenced by global environmental changes and the OA can modify the effect of infochemicals, inducing dramatic modifications in the behavior of various animals. This research takes into account the effect of volatile organic compounds produced by epiphytes growing on a seagrass and the changes induced by OA in the chemotactic reactions exhibited by associated invertebrates. Our results demonstrate that behavioural influences may hamper the survival of key species of invertebrates, besides the direct effects of OA on their physiology.

Abbreviations

OA: Ocean Acidification; VOC(s): Volatile Organic Compound(s)

Introduction

The pH of oceans decreased in the last decades due to high CO_2 emissions characterizing the industrial era [1] and a further decrease, in the order of 0.5 points, is forecasted for the next century [2]. The Ocean Acidification (OA) has evident physiologic effects on organisms equipped with external calcareous structures (e.g., coralline algae, crustaceans, corals) and this triggers immediate deleterious effects on their survival and fitness [3]. For example, a reduction of 20-40% in the calcification rates of corals has been recorded since 1880 and a further reduction is forecasted for the year 2062 [4]. Therefore, dramatic ecological changes are forecasted for the next century according to the increases of CO_2 levels in the atmosphere, trending to 520 ppm [5].

Besides the direct effects of OA on the physiology of plants and invertebrates, other consequences may be forecasted. In fact, animals use chemical cues to communicate among them and receive infochemicals produced by plants, interpreting their meaning to identify trophic resources or detect the presence of predators [6]. Infochemicals are widely diffused in the aquatic environment [7] and our knowledge of their role and importance is still in its infancy, although several researches demonstrated their importance in aerial environments [8].

The term "infochemical" [9] refers to compounds bearing information that can be received by various species living in the same environment and triggers specific reactions [10]. Volatile organic compounds (VOCs) are among the most interesting infochemicals, because they are quickly transferred to other organisms, even at a long distance from the source of production [11]. Several defence compounds [12] are produced by plants when their tissues are wounded by grazers and they can produce various effects, e.g., they can be toxic for the consumers or their progenies [13], they can produce irritation or avoidance [14], and they can indicate the presence of toxic activity [8]. These effects are quite important even to stabilize the plant and animal communities associated to complex ecosystems, as seagrasses [8]. In fact, wound-activated infochemicals [14] are readily recognized by invertebrates

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