

## Adapt or perish? Physiological and ecological strategies of the brown alga *Dictyota dichotoma* along natural pH gradients at Fuencaliente (La Palma, Canary Islands)

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Ocean acidification, driven by anthropogenic CO<sub>2</sub> emissions, is progressively altering seawater chemistry and threatening coastal ecosystems. Natural CO<sub>2</sub> seeps, such as those at Punta de Fuencaliente (La Palma, Canary Islands), provide valuable natural laboratories to investigate long-term biological responses to elevated pCO<sub>2</sub>. This study examines the eco-physiological, morphological, and anatomical plasticity of the brown macroalga *Dictyota dichotoma* along a natural pH gradient, with the aim of identifying adaptive mechanisms enabling species persistence under acidified conditions. Sampling was conducted across three zones: acidified, transitional, and control. After analysis of coverage, twenty thalli per site were screened for photosynthetic efficiency (Fv/Fm), morpho-functional traits (TDMC, STA, thallus length), pigment content, antioxidant defenses (polyphenols, tannins, antioxidant activity), carbohydrate levels, and anatomical features (cell size, tissue thickness). *D. dichotoma* showed a higher coverage under acidified conditions, likely linked to an increase in TDMC and carbohydrate content, indicating an investment of biomass in structural components, while elevated tannin levels and antioxidant activity the activation of defense mechanisms against oxidative stress. Individuals from acidified sites were also shorter and exhibited reduced tissue thickness, with significantly smaller cortical cells. In the transitional zone, low chlorophyll content and reduced STA suggested photoprotective adjustments, potentially limiting light absorption under fluctuating pH conditions. Despite these changes, photosynthesis did not vary significantly across sites, indicating the stability of the photosynthetic apparatus. Overall data demonstrated the high tolerance of *D. dichotoma* to acidified environments through a synergistic interplay of physiological, structural, and biochemical strategies. Increase in structural components, antioxidant capacity, and carbohydrate accumulation further conferred a competitive advantage under low pH conditions. These findings highlight the species' ecological plasticity and potential for local adaptation, emphasizing the value of natural CO<sub>2</sub> gradients as models for future ocean scenarios.