OPEN

The ISME Journal (2017), 1–5
www.nature.com/ismej

SHORT COMMUNICATION

Animal-like prostaglandins in marine microalgae

Valeria Di Dato[1], Ida Orefice[1], Alberto Amato[1,4], Carolina Fontanarosa[2], Angela Amoresano[2], Adele Cutignano[3], Adrianna Ianora[1] and Giovanna Romano[1]

[1]*Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Napoli, Italy;* [2]*Dipartimento di Scienze Chimiche, Università degli Studi di Napoli, Napoli, Italy and* [3]*Istituto di Chimica Biomolecolare-CNR, Pozzuoli, Napoli, Italy*

Diatoms are among the most successful primary producers in ocean and freshwater environments. Deriving from a secondary endosymbiotic event, diatoms have a mixed genome containing bacterial, animal and plant genes encoding for metabolic pathways that may account for their evolutionary success. Studying the transcriptomes of two strains of the diatom *Skeletonema marinoi*, we report, for the first time in microalgae, an active animal-like prostaglandin pathway that is differentially expressed in the two strains. Prostaglandins are hormone-like mediators in many physiological and pathological processes in mammals, playing a pivotal role in inflammatory responses. They are also present in macroalgae and invertebrates, where they act as defense and communication mediators. The occurrence of animal-like prostaglandins in unicellular photosynthetic eukaryotes opens up new intriguing perspectives on the evolution and role of these molecules in the marine environment as possible mediators in cell-to-cell signaling, eventually influencing population dynamics in the plankton.

The ISME Journal advance online publication, 28 March 2017; doi:10.1038/ismej.2017.27

Prostaglandins (PGs) are considered 'local hormones' participating in intercellular signaling, sustaining both homeostatic functions and mediating pathogenic mechanisms (Wiktorowska-Owczarek *et al.*, 2015). They are enzymatically derived from 20-carbon polyunsaturated fatty acids (PUFA) and together with oxylipins constitute a unique class of lipid derivatives known as eicosanoids (Wolfe, 1982).

PGs are present in all vertebrates, in some terrestrial (Stanley, 2006) and aquatic invertebrates (Rowley *et al.*, 2005; Varvas *et al.*, 2009), and have also been identified in some macroalgae of the genera *Gracilaria* and *Laminaria* (Sajiki and Kakimi, 1998; Ritter *et al.*, 2008).

Here we report, for the first time, the presence of PGs in marine microalgae, specifically in two strains of the diatom *Skeletonema marinoi* (FE7 and FE60), known to differ for the production of oxylipins, high in FE7 and low in FE60 (Gerecht *et al.*, 2011).

Analysing the transcriptomes of the two strains, we have identified the sequence of three main enzymes involved in PG biosynthesis (Figure 1a, Supplementary Figure S1), prostaglandin-endoperoxide G/H synthase 1 or cyclooxygenase-1 (COX-1), microsomal prostaglandin E synthase 1 (PTGES) and prostaglandin-H2 D-isomerase (PTGHI or PTGDS), and of a prostaglandin transporter (PTGT). Interestingly, we found that the FE60 transcriptome lacked the annotation for the enzyme COX-1 that initiates PGs synthesis.

Real-time-qPCR experiments confirmed the expression of these transcripts in both strains, revealing the presence of COX-1 also in the FE60 strain. Expression levels varied slightly in different phases of growth for each strain (Figures 1b–d; growth curve in Supplementary Figure S2). In particular, in strain FE7 COX-1 was down-regulated (DR) in the senescent phase with respect to the exponential phase, while in strain FE60 PTGDS and PTGT were DR in the stationary phase (Figures 1b and c). Overall, there was a lower expression level of the PG pathway in the FE60 strain compared to FE7 (Figure 1d).

The presence of prostaglandin metabolites assessed by liquid chromatography/mass spectrometry (LC/MSMS) analyses (Supplementary Figures S3 and S4) confirmed qPCR results. The identified metabolites derived not only from the main PUFA precursors eicosapentaenoic acid (EPA), the most abundant in diatoms (Stonik and Stonik, 2015), but also from eicosatrienoic (ETE) and arachidonic (AA) acids, both found in very low amounts in diatoms (d'Ippolito *et al.*, 2004). In accordance with the qPCR results, quantitative analysis revealed an overall lower production of prostaglandins in the FE60

Correspondence: V Di Dato, Department of Integrative Marine Ecology, Stazione Zoologica Anton Dohrn, Villa Comunale, 80121, Napoli, Italy. Email: valeria.didato@szn.it
[4]Present address: Laboratoire de Physiologie Cellulaire et Végétale, UMR5168 CNRS-CEA-INRA-Université de Grenoble Alpes, Institut de Recherche en Science et Technologies pour le Vivant, CEA Grenoble, 17 rue des Martyrs, 38054 Grenoble Cédex 9, France.
Received 28 April 2016; revised 18 January 2017; accepted 27 January 2017