國 立 臺 灣 海 洋 大 學
海洋環境與生態研究所 專題討論

英文題目：Small pigmented eukaryotes play a major role in carbon cycling in the P-depleted western subtropical North Atlantic, which may be supported by mixotrophy

中文題目：小型色素型真核生物在缺磷的北大西洋的碳循環中擔任重要角色可能是受到混合營養的支持

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Abstract

We found that in the phosphate (PO_4)-depleted western subtropical North Atlantic Ocean, small-sized pigmented eukaryotes (P-Euk; < 5 μm) play a central role in the carbon (C) cycling. Although P-Euk were only ~ 5% of the microbial phytoplankton cell abundance, they represented at least two thirds of the microbial phytoplankton C biomass and fixed more CO_2 than picocyanobacteria, accounting for roughly half of the volumetric CO_2 fixation by the microbial phytoplankton, or a third of the total primary production. Cell-specific PO_4 assimilation rates of P-Euk and nonpigmented eukaryotes (NP-Euk; < 5 μm) were generally higher than of picocyanobacteria. However, when normalized to biovolumes, picocyanobacteria assimilated roughly four times more PO_4 than small eukaryotes, indicating different strategies to cope with PO_4 limitation. Our results underline an imbalance in the CO_2 : PO_4 uptake rate ratios, which may be explained by phagotrophic predation providing mixotrophic protists with their largest source of PO_4. 18S rDNA amplicon sequence analyses suggested that P-Euk was dominated by members of green algae and dinoflagellates, the latter group commonly mixotrophic, whereas marine alveolates were the dominant NP-Euk. Bacterivory by P-Euk (0.9 ± 0.3 bacteria P-Euk^{-1} h^{-1}) was comparable to values previously measured in the central North Atlantic, indicating that small mixotrophic eukaryotes likely exhibit similar predatory pressure on bacteria. Interestingly, bacterivory rates were reduced when PO_4 was added during experimental incubations, indicating that feeding rate by P-Euk is regulated by PO_4 availability. This may be in response to the higher cost associated with assimilating PO_4 by phagocytosis compared to osmotrophy.

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中文摘要

作者發現小型色素型真核生物 (簡稱為 P-Euk; <5 μm) 在磷酸鹽 (PO_4) 缺乏的北大西洋的碳循環中扮演著重要的作用。雖然色素型真核生物的數量只佔了約微生物型浮游植物的 5%，但他們卻佔微生物型浮游植物 (microbial phytoplankton) 總碳量約三分之二，能比藍綠細菌固定更多的 CO_2，約佔微生物型浮游植物 CO_2 固定量的一半，或是總初級生產量的三分之一。

色素型真核生物和非色素型真核生物 (NP-Euk; <5 μm) 的單一細胞 PO4 同化率通常高於 pico 級藍綠細菌。但如果以生物體積標準化後，pico 級藍綠細菌攝取的 PO_4 大約是小型真核生物的四倍，說明了他們對於 PO_4 限制有著不同的應對策略。

本篇文章的結果強調 CO_2 : PO_4 吸收比率的不平衡，可能是因為吞噬捕食作用為混營性生物提供了大量的 PO_4。18S 擴增子定序結果顯示，小型色素型真核生物主要由綠藻與渦鞭毛蟲所做成，後者為通常是屬於混營性，然而非色素型真核生物主要則由囊泡藻所組成。小型色素型真核生物的嗜菌力 (0.9 ± 0.3 bacteria P-Euk^{-1} h^{-1}) 與前人在北大西洋中部測量的值相當，表示小型混合性真核生物可能對細菌有著相似的攝食壓力。而在培養實驗期間添加 PO_4，可觀察到小型色素型真核生物的嗜菌率降低，表明小型色素型真核生物的細菌攝食率是由 PO_4 的濃度來調節。這可能也代表了以吞噬作用同化 PO_4 比滲透作用還需要更高的成本。

參考資料

Solange Duhamel, Eunsoo Kim, Ben Sprung, and O. Roger Anderson. 2019. Small pigmented eukaryotes play a major role in carbon cycling in the P-depleted western subtropical North Atlantic, which may be supported by mixotrophy. Limnol. Oceanogr. **64**:1-17