The effects of grazing by the snail, Lymnaea elodes, on benthic N2 fixation and primary production in oligotrophic, arctic lakes

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ABSTRACT: This study assessed whether grazing by the snail, *Lymnaea elodes*, limits benthic dinitrogen (N_2) fixation and primary production in nitrogen (N)-limited oligotrophic lakes near Toolik Field Station on the North Slope of Alaska. We also tested whether snail excretion increased N and the ratio of N and phosphorus (P) supply ratio to benthic algae, which could indirectly affect production and the N_2 fixation rate. We performed *in situ*, randomized block experiments in two lakes in 3 years in which snail density was manipulated and compared to open cage controls. Snails significantly decreased areal rates of N_2 fixation in both lakes in all years ($p < 0.05$), but did not appear to cause a reduction in cyanobacterial abundance or filament size ($p > 0.05$). Snails did not significantly affect measures of benthic production, including gross primary production, respiration, net ecosystem production, and chlorophyll biomass ($p > 0.05$). Snail-induced declines in N_2 fixation probably did not result from snail excretion. The molar N: P excretion ratio of ammonium (NH_4^+) and phosphate (PO_4^{3-}) was very low (4.8), indicating that snails likely exacerbated N limitation, a response that would tend to favor enhanced rather than reduced N_2 fixation. Furthermore, the excretion rate of N-NH_4^+ was several orders of magnitude lower than the N_2 fixation rate (0.002-0.02 mg N m^{-2} day^{-1} vs. 0.1-0.4 mg N m^{-2} day^{-1}, respectively) and met almost none (<<1%) of the N demand by primary producers. Although the mechanism by which *Lymnaea elodes* caused a decline in N_2 fixation is unknown, the effect was small, and accounted for a reduction of N inputs of only 0.12 mg N m^{-2} $summer^{-1}$ or by 0.85-1.8% at ambient snail densities. Because N_2 fixation is a new N input able to support new production, this effect may be important across long time scales or where densities of *L. elodes* are higher.