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Cobalt-Driven Restructuring of the Duckweed Endophytic Microbiome Enhances Bioavailable Vitamin B₁₂

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Vitamin B₁₂ (cobalamin) is essential for animal and human metabolism, while plants neither synthesize nor require it. Yet, aquatic plants such as duckweeds can accumulate bioavailable B₁₂ synthesized by their endophytic microbiome. We hypothesized that cobalt, the central metal ion in cobalamin would enhance B₁₂ accumulation by altering endophytic community structure and function. To test our hypothesis, we cultivated the rooted duckweed species *Lemna minor* and *Spirodela polyrhiza* and the rootless species *Wolffia globosa* across a cobalt gradient, ranging from 0 to 1 μ M (just below the reported toxicity threshold). We quantified growth and bioavailable B₁₂, profiled the corresponding endophytic bacterial communities and examined B₁₂ partitioning between roots and fronds. Responses to cobalt were species-specific. In *L. minor*, B₁₂ increased by up to fivefold without affecting growth rate. Cobalt explained 54% of the variation in bacterial community composition and significantly altered the abundance of *Novosphingobium* and *Roseomonas*. In *S. polyrhiza*, B₁₂ increased by up to threefold, while cobalt explaining 38% of the variation in community composition and significantly influencing alpha diversity and overall community structure. In *W. globosa*, B₁₂ increased significantly at the highest cobalt concentration without detectable changes in community composition, suggesting regulation through microbial activity rather than taxonomic replacement. B₁₂ localization was also species-specific, with significantly greater accumulation in the roots of *S. polyrhiza* than in those of *L. minor*. These findings demonstrate that cobalt enhances microbiome derived B₁₂ accumulation in duckweed and provides a practical strategy for improving the nutritional value of duckweed biomass.

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