Bacteria relationships in aquaponics and the nitrogen cycle

Microbiota is the ecological community of symbiotic, commensal and pathogenic microorganisms within multicellular organisms, while the microbiome is the genetic material comprised a specific niche of the broader microbiota. As aquaponics is a closed system, the microbiota within aquaponics is shared between the fish gut and the plant rhizosphere. The main role of the microbiome is based on its function in maintaining homeostasis and determining nutrient bioavailability. In plants for instance, symbiotic bacteria in plant roots determine the ability to take up key nutrients such as nitrogen (i.e. fixation), phosphorus (i.e. solubilisation) and potassium. These bacteria are identified as plant-growth promoting rhizobacteria or PGPRs and participate in the regulation of lignin/cellulose ratio in the roots and interact within the endosphere and rhizoplane through biosynthesis of plant metabolites (i.e. exudates). In the fish gut, bacteria play a key role in the digestibility of feeds through nutrient breakdown and absorption. Moreover, beneficial bacterial communities aid both plants and fish to cope with biotic and abiotic stressors and pathogen threats. Microbe interactions are important to fitness in plants (i.e. expression of root phenotypic plasticity through root elongation, secondary root/hair formation and siderophore production) and health maintenance in the fish gut through immune related activity (e.g. mucosal antibody response, increased cytokine activity, cellular response and the complement system).

The main focus of bacteria relationships in recirculating aquaculture systems (RAS) has been on the nitrification process involved in biofiltration. Denitrifying bacteria play a key role in maintaining a healthy fish population given that accumulation of free ammonia is toxic to fish (i.e. NH_3 0.53 to 22.8 mg/L, pH and T°C dependant). In RAS, biotransformation of nitrogenous compounds to less-toxic forms of nitrate, that can be diluted and eliminated, is crucial for optimal culture environment as fish consume nitrogen in their feed in order to generate proteins (i.e. tissue development) and excrete ammonia after digestion (i.e. faeces). Ammonium oxidizing bacteria (e.g. *Nitrosomonas, Nitrospira*) are capable of transforming this ammonia to nitrite, while nitrite oxidizing bacteria (e.g. *Nitrobacter*) subsequently convert it to nitrate, which is a form of nitrogen that can be taken up by plants.

On the plant-side of aquaponics systems, it has been shown that plants can benefit from the natural fertilizers in fish wastes, including nitrate, but that fish wastes do not necessarily contain optimal nutrient concentrations of all growth factors required, including for instance many trace minerals. The above mentioned PGPRs increase solubility of specific nutrients (e.g. zinc, calcium, potassium and iron) in the rhizosplane and endosphere, as endophatic relationships and siderophore development enable active absorption of micronutrients through apoplastic and symplastic routes.

Bacteria relationships in aquaponics

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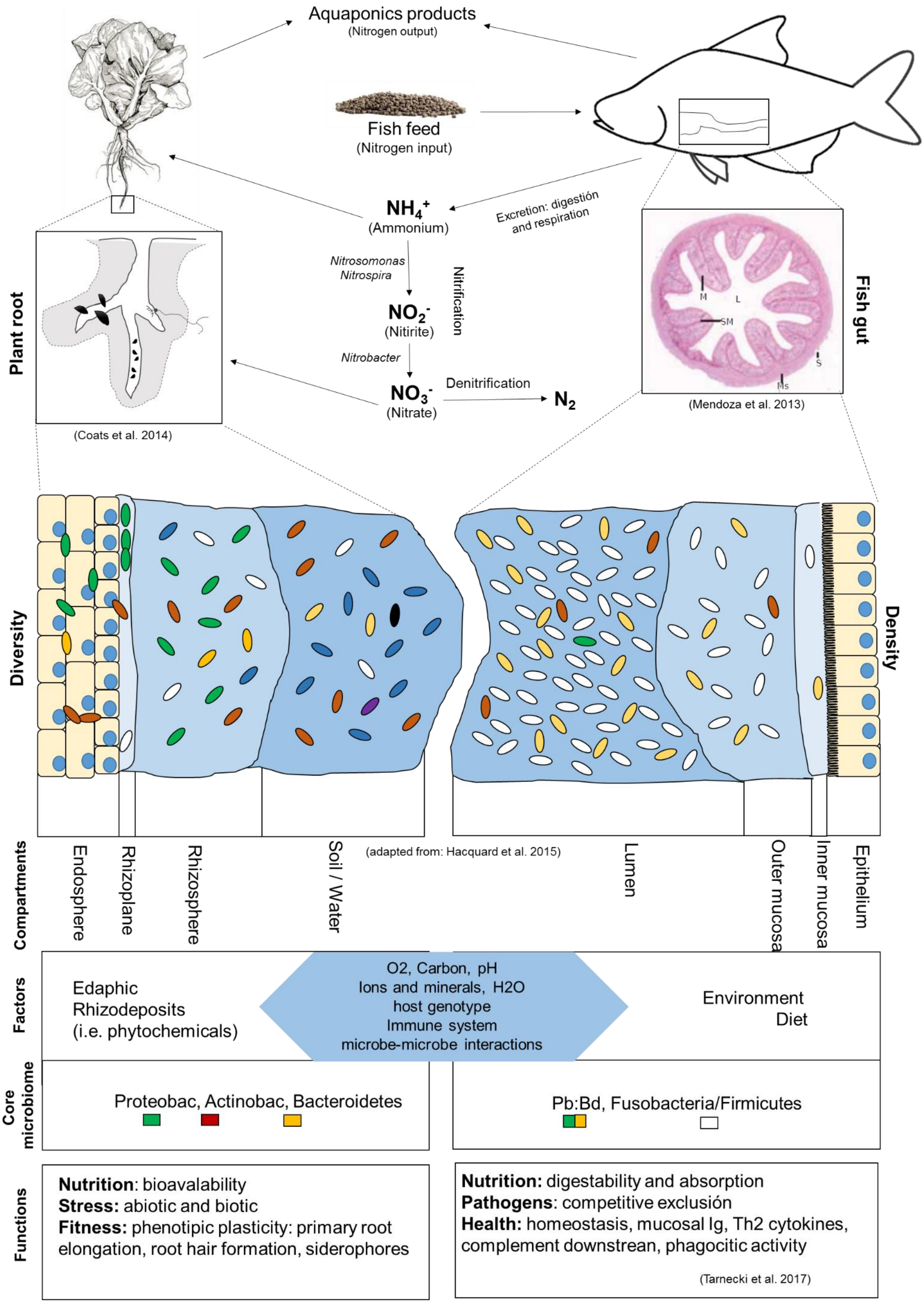

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