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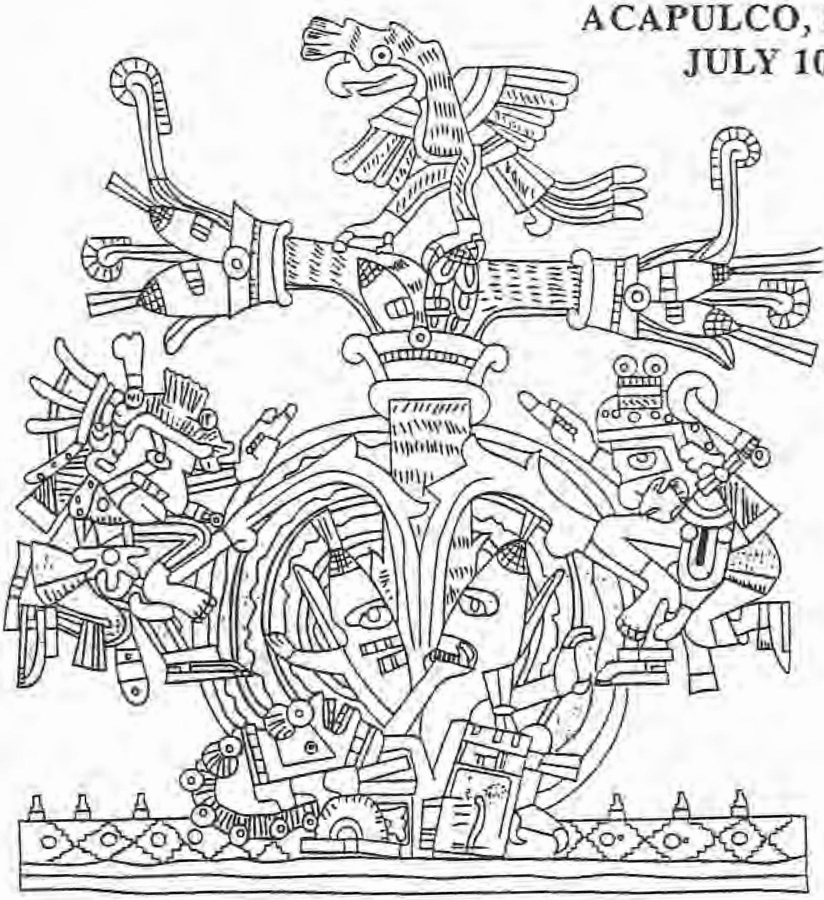

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Nitrogen Fixing and Phosphate Solubilizing Bacteria in Mangrove Communities

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Introduction. Coastal lagoons colonized by mangrove trees are one of the most important ecosystems in the marine environment. The mangrove trees provide organic matter to the ecosystem and to adjacent waters in the form of detritus which is used as food for many marine animals of commercial interest like oysters, shrimps and fish. Thus mangroves, by providing detritus to the system, support an extensive food chain. They also serve as a breeding refuge for many valuable marine and terrestrial species.

The arid climate of the Baja California peninsula, (Mexico) does not produce enough run-off to bring terrestrial nutrients to the lagoons, thus concentrations of soluble nitrogenous compounds are low. Nevertheless, the mangrove forests look "jungle-like" and show no signs of nitrogen deficiency, indicating the possibility of diazotrophic activity in this environment. Two species of new diazotrophic bacteria known as fish pathogens, were identified in the roots of mangrove seedlings (Holguin et al. 1992). Additionally, three unidentified nitrogen fixing bacteria were isolated from the rhizosphere of several mangrove species.

Phosphate rock deposits are common in southern Baja California, but the phosphate must first be solubilized before it is available to the mangrove plants. After a bacterial enrichment process, twelve phosphate solubilizing bacteria and two phosphate solubilizing fungi were isolated and purified from the rhizosphere of black mangrove seedlings after bacterial enrichment. Several isolates solubilized the rock through the production of acids, while the others operated via an unidentified mechanism(s).

Materials and Methods. Nitrogen fixing and phosphate solubilizing bacteria were isolated from Balandra bay, 25 Km north of La Paz, Baja California Sur.

Results and Discussion. The rhizosphere of mangrove plants is composed of a large variety of bacteria. Several morphotypes of these bacteria were isolated and purified. One of these isolates, Staphylococcus sp, (apparently a new species) enhanced the nitrogen fixing capacity of several species of nitrogen-fixing bacteria from either mangrove rhizosphere (Holguin et al. 1992) or from terrestrial origin like Azospirillum (Holguin et at. 1993).

Cyanobacteria were observed growing epiphytically over exposed surfaces of the red, white and black mangroves. Phototrophic diazotrophs (purple and green sulfur bacteria) were observed to be growing on submerged sections of aerial roots (pneumatophores) and in the sediments. On the aerial roots of the black mangrove, three cm above the sediment, we consistently observed communities of the cyanobacteria Lyngbya sp. and Oscillatoria sp. Between three and seven cm above the sediment, we found Microcoleus sp. and above that, Aphanothece sp. This distribution pattern was consistent, as confirmed by phase contrast and epifluorescence microscopy over a five month period. A biofilm composed of 99% cyanobacteria Anabaena sp. grew on the surrounding sediment. In situ experiments on cyanobacterial attachment to glass, wood and root surfaces showed preference to aerial roots.

In field measurements, we determined overall nitrogen fixing activity of the mangrove cyanobacterial populations on intact and excised pneumatophores . Our results showed that nitrogen-fixation on the pneumatophores, either intact or excised, occurs mainly during daytime with two activity peaks: one in the morning and the other in the afternoon when light intensity in the swamp is relatively low (400 $\mu E\ m^{-2}\ Sec^{-1}$). At midday, with light intensities reaching as high as 1800 $\mu E\ m^{-2}\ Sec^{-1}$, the nitrogen fixation activity decreased. The lowest values were monitored at midnight; however, an increase in nitrogen fixation began during the pre-dawn hours, which suggests cyanobacterial anticipation of the light energy.

Black mangrove pneumatophores are exposed many hours a day to dry conditions since the plants are in the outer zone of the mangrove community and only occasionally submerged. Nevertheless, this does not affect the nitrogen-fixing activity of the cyanobacteria, which occurred regardless of the tide cycle, water temperature, salinity or Ph. Thus, as the bacteria are attached to the pneumatophores, nitrogenous compounds can essentially diffuse from the bacteria to the plant and not be diluted or washed away by the tides. These results indicate that cyanobacteria associated with the black mangrove pneumatophores may contribute nitrogen to the mangrove plants.

To evaluate diazotrophic activity in pure and mixed culture, we isolated one strain of Microcoleus sp., five heterotrophic bacteria associated to the pneumatophores of the black mangrove, and a strain of Anabaena sp. from the biofilm on the surrounding sediment. Nitrogen fixing activity of these strains is currently being compared to field experimental data to evaluate their total nitrogen contribution to the mangrove ecosystem.

We propose that nitrogen-fixing and phosphate-solubilizing microorganisms may contribute macro-nutrients to the mangrove community and in so doing, contribute to the well being of this ecosystem.

Literature cited

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