

Changes in the diversity and composition of rhizobial communities in relation to land use systems in the rain forest of Los Tuxtlas (Mexico)



E. Ormeño-Orrillo, M.A. Rogel-Hernández, L. Lloret, A. López-López, J. Martínez, E. Martínez-Romero
 Centro de Ciencias Genómicas, Universidad Nacional Autónoma de México, Apdo. Postal 565-A, CP 62251, Cuernavaca, Morelos, México.
 Email: emartine@ccg.unam.mx

The nitrogen-fixing legume nodule bacteria known as rhizobia play an important role in maintaining soil fertility in different ecosystems. Soils from the rain forest of Los Tuxtlas, Mexico, and from the same area where forest was cleared and the land used for cropping maize with beans, pastures, or where secondary forests were established after land abandonment have been analyzed to evaluate the effects of deforestation and different land uses on rhizobial diversity.

Numbers of rhizobia in the different land use systems (LUS)

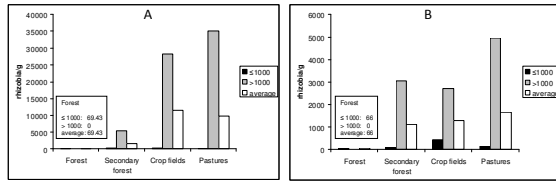


Fig. 1. Most probable number of rhizobia calculated with A) Bean and B) Cowpea as plant traps. Samples were assigned to two categories: low rhizobia (≤ 1000 rhizobia/g) and high rhizobia (>1000 rhizobia/g).

Changes in rhizobial diversity

Table 1. Diversity measures of the four land use systems (LUS)

Diversity measure	LUS			
	Forest	Crop fields	Pastures	Secondary forest
Number of strains	58	98	77	50
Observed lineage richness (S_{obs})	15	21	20	20
S_{Chao1} richness estimate	24	32	26	40
(95% CI)	(17 - 68)	(23 - 73)	(21 - 50)	(25 - 107)
S_{ACE} richness estimate	21	29	31	40
(95% CI)	(16 - 42)	(23 - 50)	(23 - 58)	(26 - 85)
Good's coverage estimate (%)	90	91.8	89.6	78
Simpson's index (1/D)	10.02	8.75	6.55	11.67
(95% CI)	(9.65 - 10.38)	(8.39 - 9.12)	(6.04 - 7.05)	(11.21 - 12.12)
Shannon's index (H)	2.36	2.47	2.35	2.61
(95% CI)	(2.17 - 2.55)	(2.28 - 2.67)	(2.1 - 2.6)	(2.36 - 2.86)

Conclusions

- Forest soils exhibited the lowest numbers of rhizobia (Fig. 1) that may be explained by the low legume density in the forest.
- A large overall richness of rhizobial species-level lineages were found at Los Tuxtlas, most of them may correspond to novel species (Fig. 2).
- Richness estimates (S_{Chao1} , S_{ACE}) did not reveal significant differences between the different LUS (Table 1). Only the Simpson diversity index seemed to reveal a higher rhizobial diversity in the forest and secondary forest soils in comparison to the crop fields and pastures (Table 1).
- The community composition of rhizobia changed dramatically when the forest soil was used for other purposes (Table 2). Some similarities were observed between the soil communities of crops and pastures but not among forest and secondary forests (Table 2).
- *Bradyrhizobium* seemed to be the most ecologically important rhizobial taxa in Los Tuxtlas, where it dominates the changes in diversity patterns (Fig. 3). The abundance of several bradyrhizobial lineages diminished in perturbed areas with two lineages no longer being recovered from agricultural and pastures sites.
- The introduction of maize and beans to Los Tuxtlas led to an increase in the abundance of *R. etli*, a bean and maize symbiont, which thus constitutes a marker species of agricultural soil use (Fig. 3).

Rhizobial lineages found in Los Tuxtlas

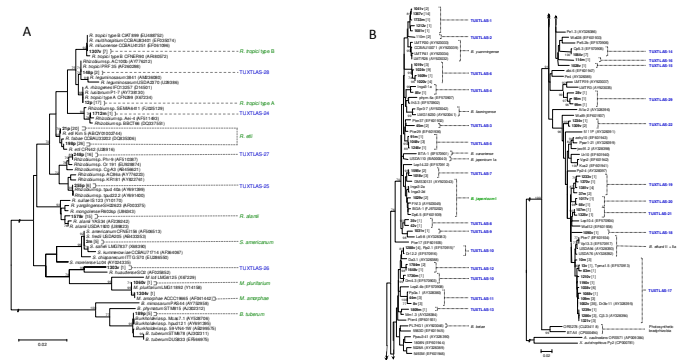


Fig. 2. Rhizobial lineages classified by A) 16S gene phylogeny for fast and intermediate growing rhizobia and B) *dnaK* gene phylogeny for *Bradyrhizobium* (slow growing rhizobia). Lineages shown in color were found in Los Tuxtlas (blue, novel lineages; green, described species). Lineages shown in black correspond to described rhizobial species that were not found in Los Tuxtlas.

Changes in rhizobial community composition

Table 2. Number of shared lineages and rhizobial community similarity indices between the four land use systems (LUS)

LUS pair		Number of shared lineages	Similarity index	
			Jaccard	Bray-Curtis
Forest	Crop fields	8	0.29	0.32
Forest	Pastures	7	0.25	0.39
Forest	Secondary forest	7	0.25	0.33
Secondary forest	Crop fields	11	0.37	0.38
Secondary forest	Pastures	9	0.29	0.36
Crop fields	Pastures	15	0.58	0.64

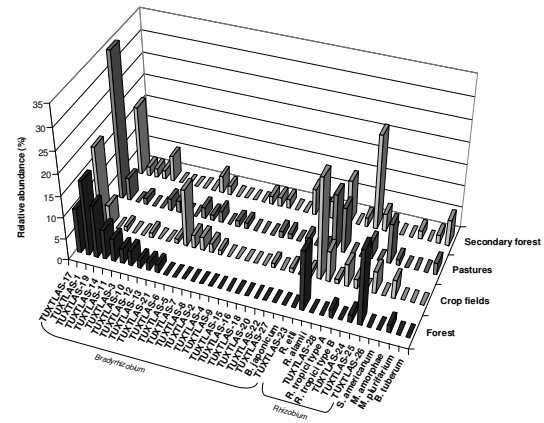


Fig. 3. Relative abundances (in percentages) of the rhizobial lineages found in Los Tuxtlas across each land use system.