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Bioturbation impact of the dominant ant *Ectatomma ruidum* sp. 2 (*E. ruidum* species complex) in Andean coffee plantations

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Bioturbation by ants can deeply impact soil physical characteristics and plant growth in agroecosystems, especially where ant nest density is high, but such an ecosystem service has rarely been studied in plantations of economic importance. We aimed at evaluating the impact of a dominant predatory ant belonging to the species complex *Ectatomma ruidum*, *E. ruidum* sp. 2, which presents nest densities estimated between 568 and 1945 nests ha⁻¹ in Andean coffee plantations of the Department of Cauca, one of the most important coffee producing areas in Colombia. A total of 120 experimental units (EUs), each containing two young seedlings of *Coffea arabica*, were established in semi-natural conditions in 20 shade or sun coffee plots. Sixty of them did not contain ant colony (controls), while a colony of *E. ruidum* sp. 2 (70 individuals on average + 1 queen) was added to the other EUs (treatments). The soil removed by ants and/or other organisms present in the EUs was collected every two days during two months, oven dried and weighted. Various variables concerning plant growth (plant height, stem diameter, plant dry weight), water infiltration, and physical properties of the soil (apparent density, percentage of micropores and macropores, total porous space) were also recorded for all EUs. On average, each *E. ruidum* sp. 2 colony removed 104.4 g dry soil during the two months of experiment (i.e., 1.58 g day⁻¹ colony⁻¹), about 13 times more than the global soil removal performed by other invertebrates (arthropods, annelids or other ant species) present on an equivalent surface during the same period of time (control EUs). Soil removal was similar in sun and shade coffee plantations. A very conservative estimate of the global bioturbation impact of this species in Andean coffee plantations was calculated at between 0.898 and 3.077 kg ha⁻¹ day⁻¹. This impact could be much higher in more natural conditions as, when considering only those *Ectatomma* colonies fully active until the end of the experiment, bioturbation was much more important, reaching up to 3.47 g day⁻¹ colony⁻¹. At the global level of the 60 colonies involved, *E. ruidum* sp. 2 seemed to affect only some of the variables related to seedling growth or soil physical properties during the two months of the experiment. However, their presence had a clear significant positive effect on all plant growth variables when only those colonies that were active until the end of the experiment were considered. Conservation of soil nesting ants by avoiding pesticides should be considered in the light of the functional role of these ants for bioturbation in agroecosystems.

Bioturbation impact of the dominant ant *Ectatomma ruidum* sp. 2 (*E. ruidum* species complex) in Andean coffee plantations

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Introduction

Ant bioturbation can deeply impact soil physical characteristics and plant growth in agroecosystems. We evaluated the impact of the predatory ant *Ectatomma ruidum* sp. 2 (nest densities of 568 to 1945 nests ha⁻¹) in Andean coffee plantations of the Department of Cauca, one of the most important coffee producing areas in Colombia.



Fig. 1. Sun and shaded coffee plots (A) where EUs with or without colonies of *Ectatomma ruidum* sp. 2 (B) were installed.



Fig. 2. Soil particles removed during nest excavation in a treatment EU (A) and nest structure (B).



Methods

- ◆ 120 experimental units (EUs) with two young seedlings of *Coffea arabica* were established in semi-natural conditions in 20 shade or sun coffee plots: 60 controls without *E. ruidum* sp. 2 colony, 60 treatments with a colony (≈ 70 workers, 1 queen).
- ◆ Soil removed by ants and/or other organisms present in the EUs was collected every two days during two months, oven dried and weighted.
- ◆ Various plant growth variables (plant height, stem diameter, plant dry weight), water infiltration, and physical properties of the soil (apparent density, percentage of micropores and macropores, total porous space) were also recorded for all EUs.

Results & Discussion

- ✓ 104.4 g dry soil removed per colony during the two months of experiment ($1.58 \text{ g day}^{-1} \text{ colony}^{-1}$), ≈ 13 times more than in control EUs.
- ✓ No differences between sun and shaded coffee plantations.
- ✓ The impact could be much higher in more natural conditions. The 14 *Ectatomma* colonies fully active until the end of the experiment removed $3.47 \text{ g day}^{-1} \text{ colony}^{-1}$.
- ✓ Bioturbation concentrated during the first 4 weeks of nest excavation.
- ✓ Conservative estimate of bioturbation impact: 0.9 to $3.1 \text{ kg ha}^{-1} \text{ day}^{-1}$ in Andean coffee plantations; but up to 9.3 to $18.2 \text{ kg ha}^{-1} \text{ day}^{-1}$ in regions with higher nest densities (Panama, southern Mexico).
- ✓ At the global level of all treatment EUs, *E. ruidum* sp. 2 affected only few variables related to seedling growth or soil physical properties. However, their presence had a clear significantly positive effect on all plant growth variables in the EUs with colonies active until the end of the experiment.
- ✓ Conservation of soil nesting ants by avoiding pesticides should be considered in the light of the functional role of these ants for bioturbation in agroecosystems.

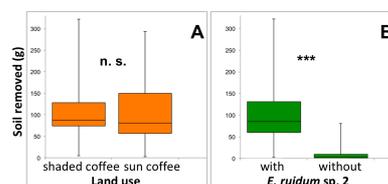
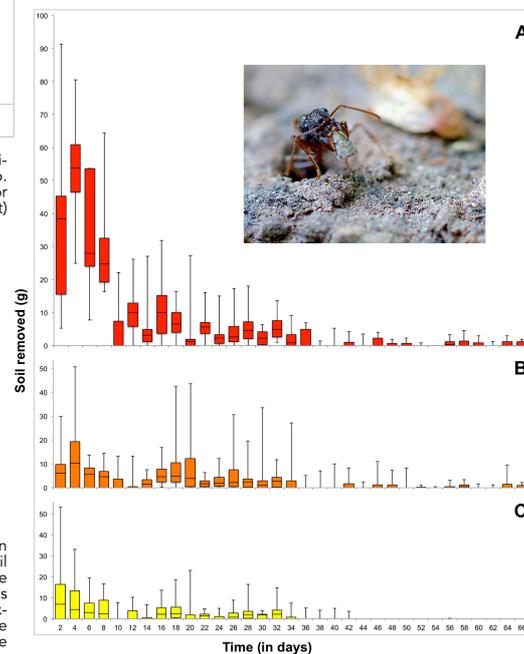


Fig. 3. Cumulative soil removal during the experiment: A) in sun and shaded coffee with *E. ruidum* sp. 2 ($n = 30$ for each land use); B) in all the EUs with or without *E. ruidum* sp. 2 ($n = 60$ for each treatment) (n.s., not significant; *** $P = 2e-16$).



Fig. 4. Kinetics of soil removal by *E. ruidum* sp. 2 in sun and shaded coffee plots during 66 days. A) Soil removal in the 14 EUs with colonies active until the end of the experiment. B) Soil removal in the 23 EUs with colonies showing low activity during all the experiment. C) Soil removal in the 23 EUs where colonies did not remain active until the end of the experiment.



Variable	Land use	Theoretical t	Observed t	p
Length from the main root tip	Shaded	2.14	3.38	0.0045
Seedling length	Shaded	2.14	3.40	0.0043
Micropores field capacity	Shaded	2.14	2.37	0.0325
Stem diameter	Sun	2.23	2.95	0.0144

Table 1. Comparison (Student-t test) between theoretical (null hypothesis) and observed data obtained for four variables recorded in the 14 EUs with *E. ruidum* sp. 2 colonies presenting activity until the end of the experiment (6 in sun coffee, 8 in shaded coffee).