Recovery of ant diversity in the Atlantic Rain Forest of Brazil

J.H. Bihn[1,2], M. Verhaagh[1], M. Brändle[2], R. Brandl[2]

Introduction

The loss of tropical forests is one of the major processes leading to the recent burst in species extinctions. Deforestation, however, is rarely total or permanent. Small patches of original habitat remain and succession leads to secondary forests which may act as secondary habitats for forest-adapted species. As secondary forests are increasing in area throughout the tropics, their potential value for the conservation of biodiversity is increasing, too. Hence, the conservation and management of secondary forests will be a crucial factor to secure the future of biodiversity in tropical forests.
We examined the diversity of leaf litter and soil ant assemblages along a successional gradient from pastures through three stages of secondary forest to old-growth forest in the Atlantic Forest in Southern Brazil.
Our study was designed to investigate three important aspects of ant diversity during secondary forest succession. In particular we tested 3 hypotheses:

Hypothesis 1: *During succession richness and composition of the ant assemblage gradually approach the conditions in old-growth forests.*

Hypothesis 2: *Differences in physical and chemical properties among soil types affect ant diversity during forest succession.*

Hypothesis 3: *The belowground ant assemblage exhibits a lower resilience (i.e. speed of return to the reference state) than the aboveground ant assemblage.*

Materials & Methods

Sampling methods:

In each study site (n = 21) we established two 50 m long parallel line transects (20 m between) and collected litter and soil samples at intervals of 10 m resulting in 10 litter samples and 10 soil samples.
For the litter samples we collected all leaf litter and twigs inside a 1 sqm quadrate and ants were extracted by sieving through a 1 cm mesh and leaving the sifted material in Winkler bags for 3 days. Soil samples were taken by digging up cubes (15x15x10 cm) from the upper soil layer (without leaf litter) followed by extraction of the fauna using Berlese funnels which employed light bulbs as the source of heat for 21 days.

Sampling design:

Number of replicated sites for each combination of successional phase and soil type

Tab. 1. Successional phases (years after abandonment of pastures)

	phase 1 (~ 5 years)	phase 2 (10-15 years)	phase 3 (35-50 years)	phase 4 ()
Soil type				
Cambisol	3	3	3	3
Gleysol	3	3	3	0 (not available)

Results

Richness of ant assemblage

Fig. 1. Mean genera richness (± SE) per study site (n = 3; a & b), mean genera richness after rarefaction (± SE) to a common number of occurrences (c & d) and geometric mean (± SE) of genera density for litter ants and soil ants at different phases of forest succession (e & f).

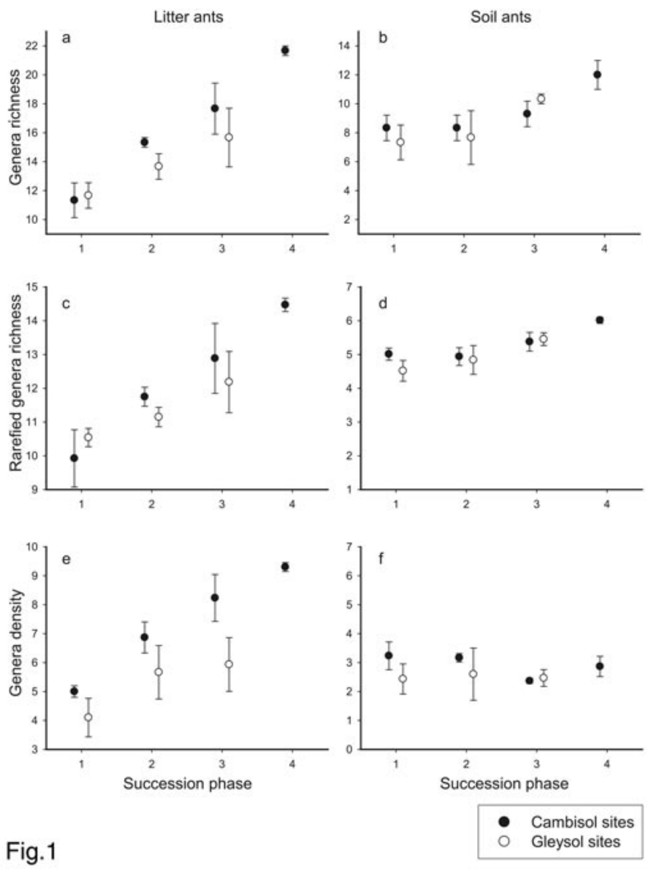


Fig.1

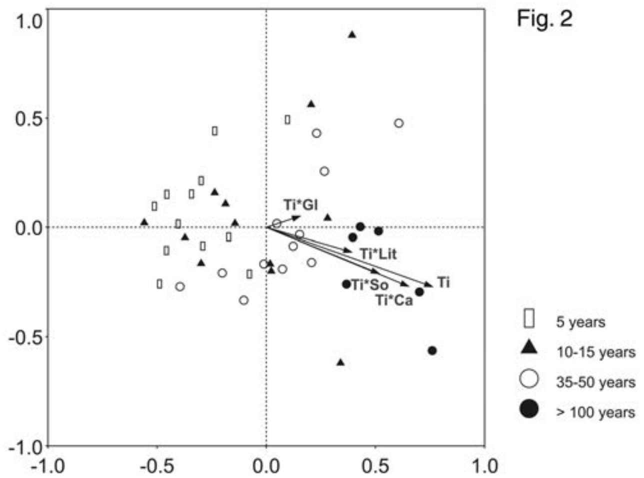
Tab. 2. Results of ANOVA for the effect of successional phase, interaction soil type*successional phase and interaction habitat*successional phase on different estimates of ant diversity.

Tab. 2	Genera per site	Rarefied genera per site	Genera density
successional phase	$p < 0.01$	$p = 0.01$	$p < 0.01$
Soil type* successional phase	n.s.	n.s.	n.s.
Habitat* successional phase	$p = 0.03$	$p < 0.01$	$p = 0.01$

Composition of ant assemblage

Fig 2. Principal component analysis (PCA) ordination plot illustrating similarity of ant assemblage between different study sites. Soil type (Gleysol, Cambisol) and habitat (soil, leaf litter) were used as covariables in the analysis. Vectors of environmental variables are post hoc projected. Ti = succession phase; Ti*Lit & Ti*So = interaction between succession phase and habitat (soil, leaf litter); Ti*Gl & Ti*Ca = interaction between succession phase and soil type (Gleysol, Cambisol).

Fig. 2



Tab 3. Results of NPMANOVA for the effect of successional phase, interaction soil type*successional phase and interaction habitat*successional phase on genera composition.

Tab. 3	Genera composition
Successional phase	$p < 0.05$
Soil type*successional phase	$p < 0.05$
Habitat*successional phase	n.s.

Resilience of ant assemblage

Fig. 3

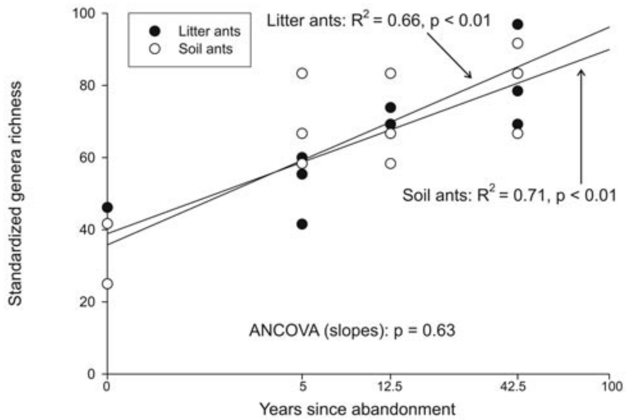


Fig. 3. *Standardized genera richness* (% of richness in old growth forest) vs. $\log_{10}$ (years since abandonment +1) by habitat (soil, leaf litter). Each point represents the standardized genera richness of the soil or litter ant assemblage at a site during forest regeneration.

Fig. 4

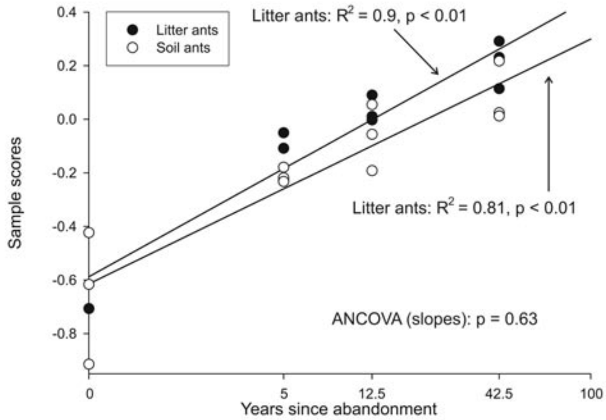


Fig. 4. *Genera composition vs.* $\log_{10}$ (years since abandonment +1) by habitat (soil vs. leaf litter). Each point represents the sample score on the first axis of a PCA (Fig. 4) of the soil or litter ant assemblage at a site during forest regeneration.

Interpretation

- As succession after abandonment of pastures proceeds, composition and richness of the ant assemblage gradually approach conditions in old growth forests but even after 35-50 years the ant assemblage was distinctly impoverished in comparison to old growth forests.
- Our study demonstrated that the recovery of ant diversity depends on soil conditions, especially the recovery of community composition. The recolonization potential of the associated communities might vary and biodiversity in secondary forests on different soil types may differ in the reaction to anthropogenic disturbances.
- The belowground and aboveground ant assemblages do not differ in the overall speed of recovery. In the first 50 years of forest regeneration genera richness and composition increased asymptotically to levels in old growth forest.

Conclusions

- Edaphic conditions may modulate the regeneration of biodiversity in tropical forests. The effectiveness of the protection of secondary vegetation for local biodiversity conservation depends therefore at least partly on prevalent soil conditions.
- Complete recovery of the ground living ant assemblage is estimated to occur after >100 years. Aboveground and belowground ant assemblages exhibit comparable resilience to anthropogenic disturbance.
- Secondary forest can give home to many forest species and play an important role as buffer zones around old growth forests but the priority in biodiversity conservation should be directed to the scarcely remaining primary forests with their unique species in this biodiversity hotspot.

1) State Museum of Natural History Karlsruhe
Department of Entomology
Erbprinzenstr. 13, 76133 Karlsruhe, Germany
jochen.bihn@smnk.de

2) University of Marburg
Department of Animal Ecology
Karl-von-Frisch Str. 1, 35032 Marburg, Germany