Changes in arthropod diversity with successional stage in a cloud forest

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Abstract. We sampled the arthropod morphospecies composition of the shrub layer in forest stands of 3 successional stages (10 yr and 25 yr secondary, and primary forest) and in a pasture. We predicted that: a) species diversity and evenness would increase along a successional gradient from pasture to primary forest; and b) highest morphospecies overlap would be found between sites closest in successional sequence. There was no substantial difference in arthropod diversity but morphospecies composition differed among sites, with species overlap greatest among adjacent habitats in the successional sequence. Only 30% of primary forest morphospecies were found in the 25 yr secondary forest, suggesting a slow recovery rate of arthropod fauna.

Key Words: forest regeneration, secondary forest, agriculture

Introduction

Arthropods are an important aspect of forest community structure because of their species diversity and their diverse roles as consumers, pollinators, and prey. Clearing primary tropical forest for agriculture has been shown to cause drastic decreases in arthropod diversity and species composition (Power, 1996). There is little species overlap between agricultural land and natural forests in Costa Rica (Janzen, 1973). We sampled arthropod diversity and morphospecies composition in 4 habitats of differing successional stage to determine the effect of forest development on arthropod communities. We predicted: a) that arthropod diversity would increase as habitats progressed from pasture land to primary forest and b) that morphospecies overlap should be highest between sites that are closest in successional order.

Methods

We sampled arthropods in 4 different habitat types surrounding La Estación Biológica Monteverde, located in and around the cloud forest at Monteverde, Costa Rica. The sites varied in successional stages: an agricultural area, a 10 year old forest, a 25 year old forest, and a primary forest.

Study site. The agricultural area was a pasture dominated by short grasses (ca. 0.5 m tall), with a few fruit trees. The 10 yr forest was a dense stand dominated by pioneer species. The 25 yr forest was similar to the 10 yr forest, but with a more open understory and more large trees. The primary forest had a still more open understory, with diverse canopy and understory trees. The secondary and pasture sites were within 400 m of primary forest, the 25 yr old forest site being closest to primary forest (50 m).

Arthropods were sampled 0-2 m above the ground (i.e. in the shrub layer) in each habitat. At each site, 4 sweep-net samples (with 60 sweeps in each) were taken over two days, ranging from morning to late evening. Eleven pitfall traps were left in each of the 4 sites for 24 hours. At each site, 3 pitfall traps were baited with honey, 3 with banana, and 5 were unbaited. In the primary forest, 3 of the 11 pitfall traps were dug up by animals overnight, reducing our sample for that site.

Arthropods were classified to morphospecies, including larval forms. Dipterans (which were abundant) and isopods were excluded from our analysis. The diversity and evenness of morphospecies between sites was compared using the Shannon diversity index.

Results

We found a total of 236 arthropod morphospecies. The number of singlets (morphospecies represented by one individual) was 40 in the pasture site, 25 in the 10 yr old forest, 53 in the 25 yr old forest, and 55 in the primary forest (Fig. 1).

The Shannon diversity index was approximately equal across all 4 successional stages (when a very abundant homopteran morphospecies in the 10 yr site was excluded; Table 1). However, primary and 25 yr old forests had the most morphospecies (Table 1). Four orders found in the primary site were not represented in the pasture site (Dermaptera, Opiliones, Thysanura, and Blattaria).

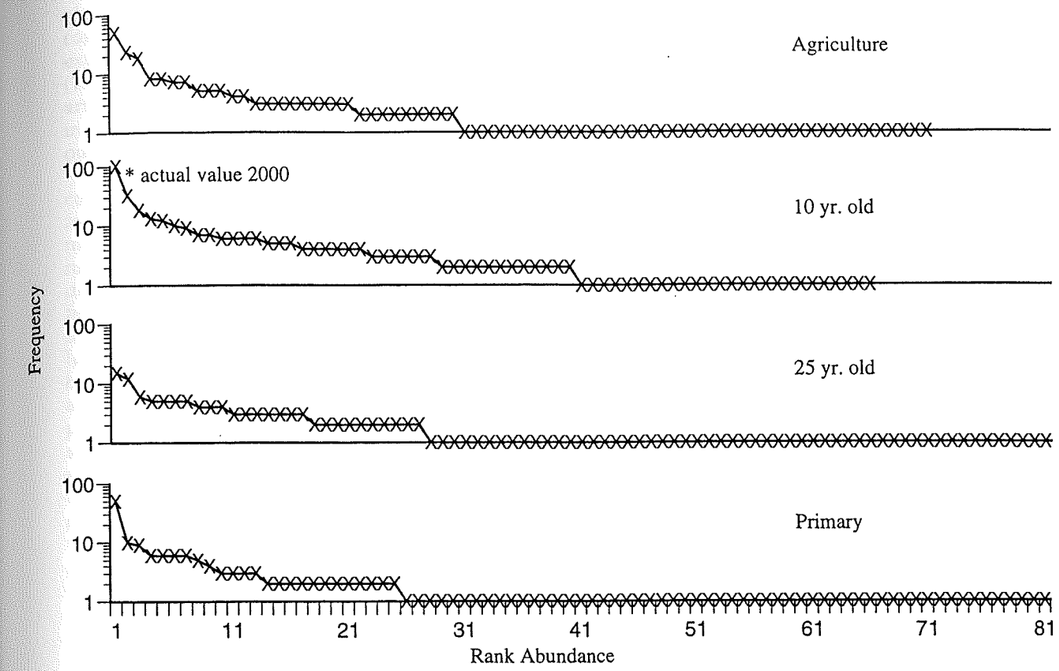

Fig. 1. Ranked abundances of arthropod morphospecies from 1 agriculutral and 3 forest habitats at La Estacion Biologica de Monteverde, Costa Rica.

Table 1. Diversity and evenness of morphospecies at 4 habitat types, Monteverde, Costa Rica. Values in parentheses exclude an abundant homopteran morphospecies in the 10 yr forest.

	Agriculture	10 Year Forest	25 Year Forest	Primary Forest
Total Individuals	229	2240 (240)	160	194
Total Morphotypes	71	67 (66)	81	81
Total Orders	7	10	9	11
Shannon Diversity Index (H)	3.46	0.73 (3.68)	4.03	3.59
Evenness (J)	0.81	0.17 (0.88)	0.92	0.82

Morphospecies composition of the shrub layer differed among the 4 successional stages. Agricultural and 10 yr old forest sites had a higher percentage of "plant-sucker" morphospecies (homopterans and hemipterans) than the older forests. The percentage of arachnid morphospecies was higher in the 25 yr and primary forests than in the two early successional sites (Fig. 2). The percent overlap of morphospecies between the primary forest and other sites increased with successional stage: 16% in the agriculture area, 25% in 10 yr forest, and 30% in 25 yr forest (Fig. 3).

Discussion

Our data suggest that the 4 sites had similar levels of diversity in the 0-2 m layer, but contained very different species compositions. Although the agricultural site lacked 4 orders found in the forest sites, the numbers of morphospecies, diversity indices, and rank abundance curves all demonstrated similarity in richness and evenness among the 4 sites.

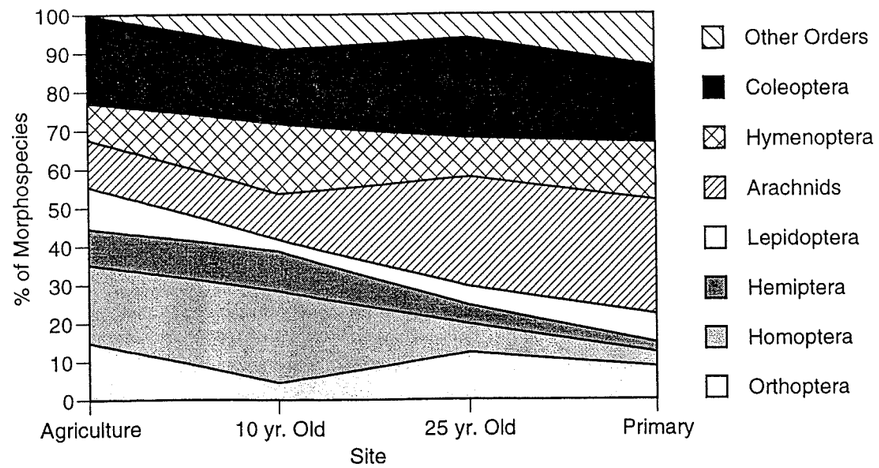

Fig 2. Percent of total morphospecies in each arthropod order for 4 sites of differing successional stage at La Estación Biológica Monteverde, Costa Rica.

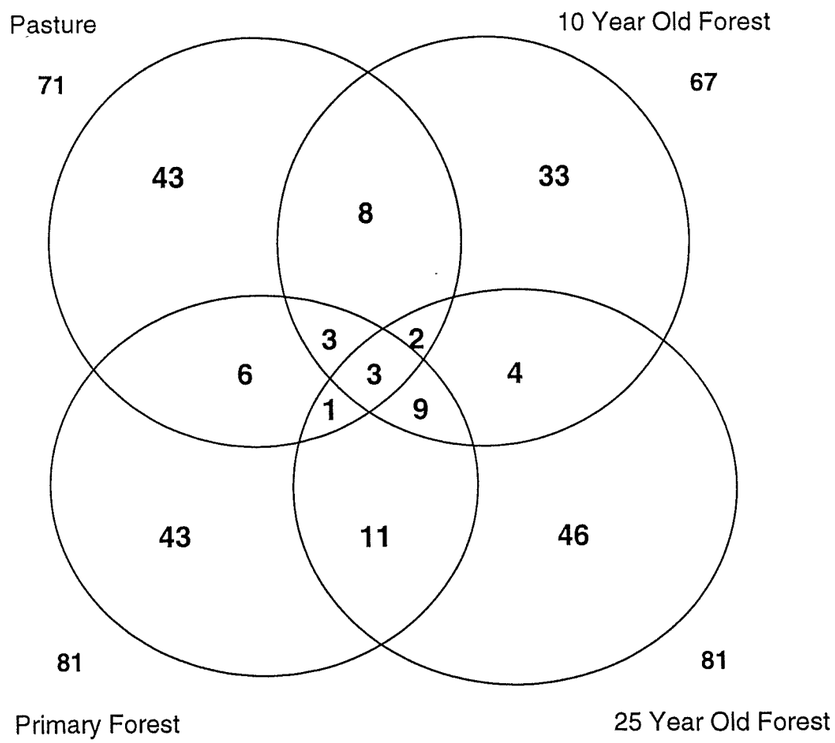

Fig 3. Number of arthropod morphospecies, and overlap between 4 sites of different successional stages at Monteverde, Costa Rica. Overlap between diagonals are not shown (5 morphospecies overlap between 10 year old and primary forest, 5 morphospecies overlap between the agriculture site and 25 year old forest). The total number of morphospecies identified (all sites combined) was 236.

However, it is important to note that in older, more developed forests, increased canopy complexity creates microhabitat diversity that extends well above the 0-2 m layer we sampled (Wilson, 1992). Thus, the total diversity of arthropods in older successional, and especially in primary, forests would be much greater than our samples from the 0-2 m layer alone indicate.

The differences in morphospecies composition among the 4 sites is most apparent for arachnids and plant suckers. More arachnid morphospecies in older forests suggests a richer, more developed predator community. The decrease in plant sucker diversity in older forests may be due to increased plant defenses in primary forest or lower biomass in the shrub layer. The trends in morphospecies overlap between sites suggest a successional trend in arthropod composition from the pasture to primary forest. This is expected, due to the successional trend in plant species composition, as well as the development of physical structure in the forest and forest floor. However, the low percentage of shared morphospecies between the primary and 25 yr forest (despite their close proximity) suggests that a return to primary forest arthropod species composition is likely to take many decades. It would be valuable to sample more extensively to determine whether the successional trends in morphospecies overlap that we observed are robust.

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