MYRIAPODA COMMUNITIES IN A REFORESTATION AREA AND MATURE FOREST IN CAT TIEN NATIONAL PARK

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1. INTRODUCTION

Forest cover is decreasing rapidly in many areas of our planet caused by human activity, and tropical regions are under the hardest pressure [1, 2, 3]. Forests are cut down for many reasons including massive issues such as making timber storage and cleaning areas for different crop plantations [3, 4, 5]. Vietnam, as with many other countries with a tropical climate suitable for coffee, rubber, and cashew plantation, and rapidly increasing human population, loses forest cover with a dramatic rate [6, 7, 8]. Moreover Vietnam lost a lot of forest area during the Vietnam War [9, 10, 11]. In the last decades in many countries including Vietnam a lot of efforts are used for protection of forest cover and for running reforestation programs [12, 13]. However agricultural use of land changes ecosystem and especially soil cover significantly which makes reforestation more problematic [4, 8, 14]. There is also a lack of information and experience about reforestation strategies in tropical regions [13, 15, 16]. Little is known about community dynamics in recovering forests and markers for controlling its successfulness [17, 18]. Millet J. with his team created their own reforestation program for lowland tropical forest with Dipterocarpaceae as the dominant trees and in 1996 they started this program in Cat Tien National Park, Southern Vietnam [19]. The author together with Goncharov A. and Tsurikov S. (both from A.N. Severtsov Institute of Ecology and Evolution RAS, Russia) investigated Millet's plantations after 20 years to study soil community structure under young planted forest in comparison to native forest in the same area. In this part of the work the author focused on Myriapoda, mainly classes Diplopoda and Chilopoda, also the author took into account Symphyla. The Diplopoda community in Cat Tien National Park is well studied [20] and appears as one of the main taxa after termites in primary destruction of dead plant material. Chilopoda appears as one of the top predators in soil food chains and by this affects the entire saprotrophic community. The soil saprotrophic community is responsible for utilization of dead plant material and for its transformation into nutrients available for plants; in general the saprotrophic community makes a great contribution to ecosystem functioning and stability. Myriapoda diversity, abundance, and community structure, as part of the soil community, are one of the markers for evaluating ecosystem quality.

2. MATERIALS AND METHODS

Study sites

Sampling was performed in two model areas, namely reforestation area and mature tropical forest, in Nam Cat Tien National Park belonging to Dong Nai forest reserve, Southern Vietnam (11º N, 107º E, about 120 m a.s.l.). Park territory is

covered by secondary and partly primary lowland forest with dominating first level trees *Afzelia xylocarpa*, *Lagerstroemia calyculata*, *Tetrameles nudiflora* and Dipterocarpaceae species (for detailed description of forest structure and species composition see [21]). The National Park territory has a monsoon climate with strongly marked dry and rainy seasons; the mean annual air temperature is 26°C, annual rainfall is 2470 mm with rain mostly occurs in May-September [22]. The leaf litter layer is present mainly in the dry season (2-12 cm thickness), and in the rainy season it shortly disappears. Soil in sampling areas is classified as thin clayey brown tropical soil, or Dystric Skeletic Rhodic Cambisols (Clayic) according to the WRB system [23].

The reforestation area is covered by planted forest with the same dominant tree species as in natural forest; it was founded in 1996-98 by Millet team [19].

Sampling method

Animals were extracted by soil sampling; standard sample includes 25x25x20 cm section of soil and 50x50 cm leaf litter; soil sections were separated for upper soil layer (0-2 cm depth), middle layer (2-10 cm), and the deepest layer (10-20 cm). Animals were extracted from samples immidiately in the field by hand sorting. Animals from leaf litter samples were extracted by Tullgren funnels in lab conditions. Collected animals were placed in alcohol solution (75%) and afterwards identified.

In October-December 2011 preliminary sampling was performed in two model plots in reforestation area: dry plot and wet plot (dry area with plantations founded in 1996 and wet area founded in 1998 [19]). 9 soil samples were taken at each model plot. In November-December 2016 and January 2017 sampling was performed in three plots with different humidity (B, C and D plots); 8 samples were taken in each model plot. In the same time in 2016-17 forest area was also sampled; 8 samples were taken there.

3. RESULTS AND DISCUSSION

The leaf litter layer moisture differs in model plots (fig. 1); the driest plot was B (23.5±6.1%), the wettest was D (30.9±14%). The forest leaf litter was much more humid (51.2±6.2%). The temperature of leaf litter and soil layers differed not much among model plots (fig. 1B) but was much less and more uniform among layers in the forest plot. More stable conditions in the forest ground layer are related to multiple overlapping canopies shielding the understory from sun and wind flows. In the reforestation area there is only one layer of partly closed canopy and one layer of undergrowth and bushes. Direct sun reaches the leaf litter surface during the day and leads to faster drying and increasing temperature. Another factor that stressed the effect of insolation on leaf litter and soil is prevalence of deciduous tree species in a planted area. During the dry season most trees lose their leaves and the ground layer becomes exposed to direct sun, while in mature forest several understory layers protect the ground even in the dry season [17].

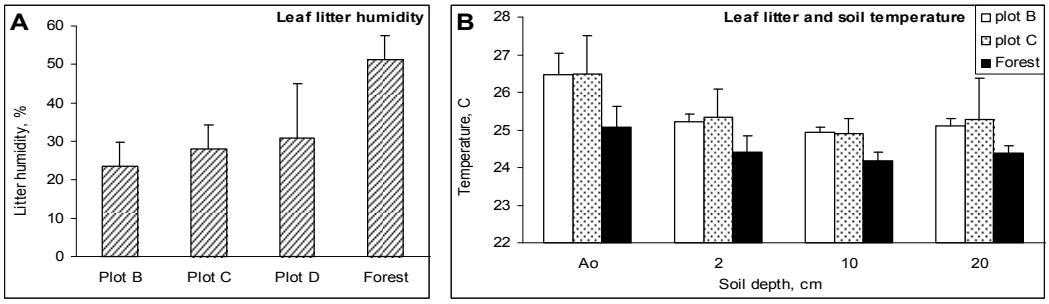

Fig. 1. Abiotic conditions at sampling area. A: Leaf litter layer humidity; B: Temperature of different soil layers. The averaged data are shown with standard deviation (n = 8)

In the reforestation area millipedes and centipedes colonized mainly upper soil layers (0-10 cm in depth) and appeared in much smaller numbers in deeper soil (more than 10 cm). They were also much less abundant in the leaf litter layer (fig. 2). In the forest Myriapoda also preferred upper soil layers but also colonised the leaf litter layer. Lack of animals in leaf litter in the reforestation area must be caused by hard abiotic conditions in that area [17]. Centipedes and especially millipedes are water dependent animals and in general prefer moist shady habitats [24]; dry and hot conditions in the reforestation area make leaf litter less suitable for animals.

Myriapoda were more abundant in the forest than in the reforestation area (276±202.5 ind/m^2 in forest and 39.1±21 ind/m^2 in reforestation area, data is shown in fig. 2 with soil depth detailed). However Myriapoda abundance in the reforestation area changes with time. In 2011 Myriapoda abundance was 18.2±12.6 ind/m^2 in both investigated plots, but in 2016 it was 52.9±9.2 ind/m^2. Planted forest also changed during that period; if in 2011 the canopy was not closed at all and bushes and undergrowth trees were quite rare, in 2016 the author found lots of small trees and bushes, the canopy was partly closed, and lianas and epiphytes became abundant on tree trunks. Those changes draw reforestation plantation structure closer to native forest structure and in the Myriapoda community the author found a similar dynamic.

Water regime significantly affects Myriapoda distribution (fig. 3). In 2011 the author found that millipedes mostly avoided the plot with high humidity; centipedes were present in both plots but in the dry one they were more abundant (18.2±7.5 ind/m^2 in dry plot and 8.9±4.9 ind/m^2 in wet plot). As millipedes have little mobility they avoid non-suitable habitats, but centipedes are more mobile so are able to colonize flooded areas soon after water has gone [25].

In 2016 the driest plot, B was highly colonized by millipedes but they were also quite abundant in other plots (fig. 4A). In the driest plot millipedes prefer habitats in soil but in wetter plots they also appear in the leaf litter layer. Centipedes were as abundant as millipedes and preferred wetter plots. Centipedes colonized soil and were almost absent in the leaf litter layer. In the case of a dramatic flooding disturbance Myriapoda preferred the dryer area as was found in plots investigated in 2011, but in more stable conditions animals tend to inhabit wetter sites as in plots the author investigated in 2016.

In forest millipedes were much more abundant than centipedes (in average 147.4±51.3 ind/m2 of millipedes and 54.9±21.7 ind/m2 of centipedes, data is shown in fig. 5 with soil depth detailed).

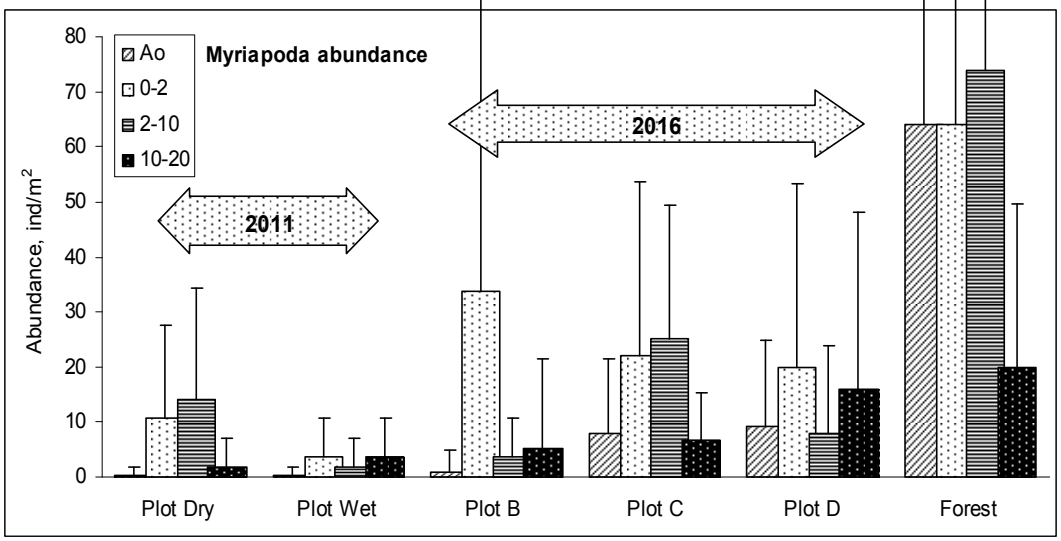

Fig. 2. Abundance of Myriapoda (Chilopoda, Diplopoda, and Symphyla) in different soil layers in all investigated plots. Averaged data are shown with standard deviation, n = 8-9

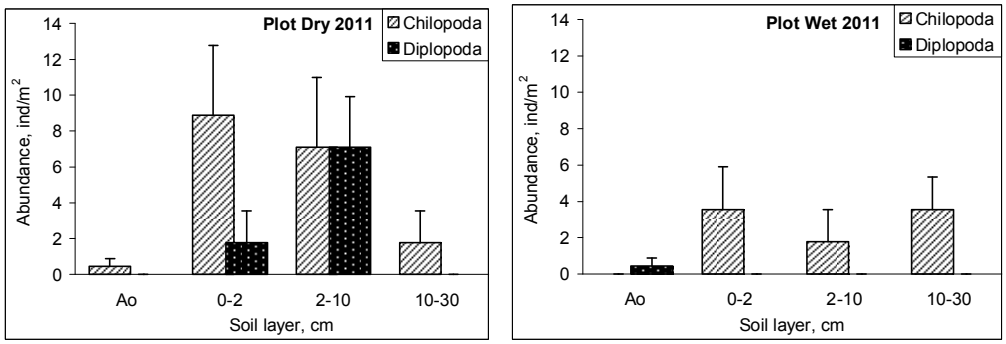

Fig. 3. Abundance of Chilopoda and Diplopoda in Reforestation plots at 2011; averaged data for different soil and leaf litter layers are shown with standard error

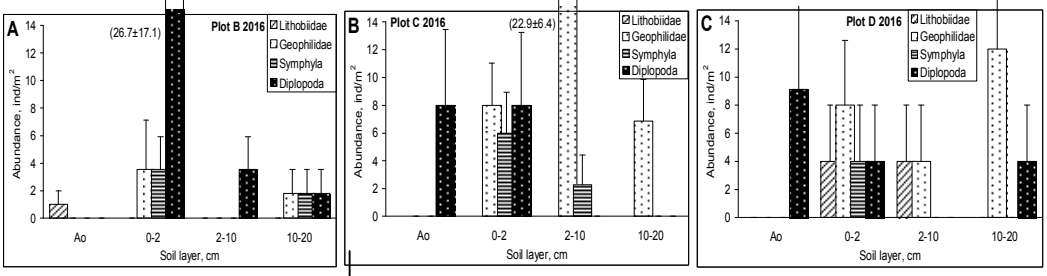

Fig. 4. Abundance of Chilopoda (Lithobidae and Geophilidae), Symphyla and Diplopoda in Reforestation plots in 2016; averaged data for different soil and leaf litter layers are shown with standard error. A: Plot B; B: Plot C; C: Plot D

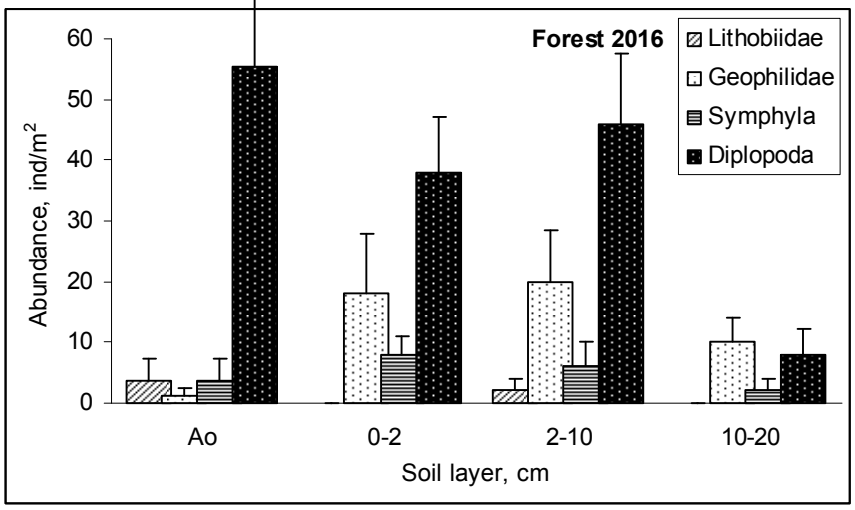

Fig. 5. Abundance of Chilopoda (Lithobidae and Geophilidae), Symphyla and Diplopoda in Forest plot in 2016; averaged data for different soil and leaf litter layers are shown with standard error

Millipede community in the forest consists of 10 species and was more diverse than in the reforestation area (6 species, fig. 6). The forest community was also more balanced while in the reforestation area two species dominated highly and others were much less abundant. High domination by several species is typical for disturbed communities while middle disturbed communities have more balanced structure as it is in investigated forest plots [26, 27, 28]. While centipedes are quite mobile animals and they occupy suitable habitats quickly, millipedes have low dispersal ability and reach high density and species diversity only after community stabilization [29]. The author observed an increase in Myriapoda abundance in the reforestation area between 2011 and the start of 2017 which can be taken as a mark of developing the reforestation community into a community similar to native forests.

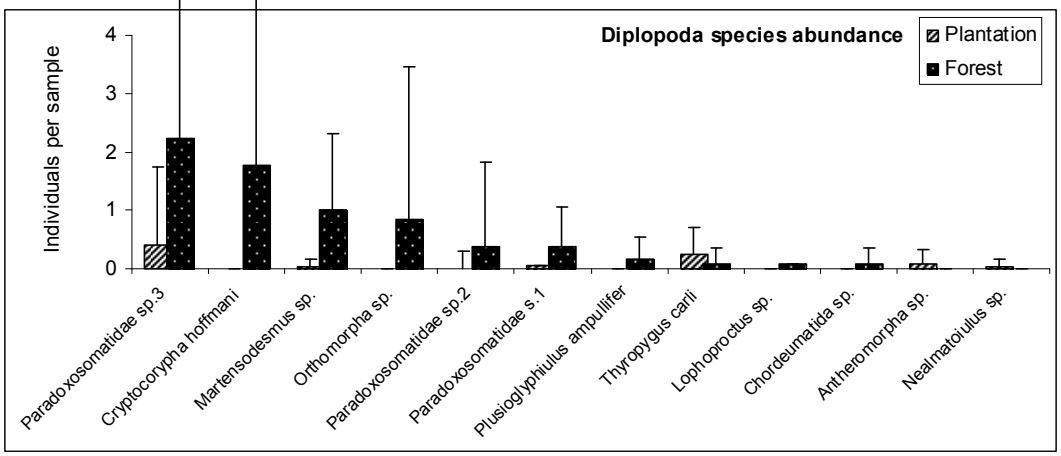

Fig. 6. Diplopoda species abundance in reforestation area and in forest, data of sampling in 2016, averaged data for samples are shown with standard error.

4. CONCLUSIONS

The Myriapoda soil community in 20-year old planted forest in Cat Tien National Park differs from the community in mature forest in the same area. It can also be related to youthfulness of planted forest which causes abiotic conditions to differ from mature forest and to be less suitable for Myriapoda. The Myriapoda community over time (from 2011 to the start of 2017) develops into a community more similar to one in mature forest. Further studies are needed for getting knowledge about successional processes in planted forest in tropical areas and for marking out parameters of its successfulness.

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SUMMARY

The Myriapoda community of 20-year old replanted forest surrounded by native lowland monsoon tropical forest in Cat Tien National Park, Southern Vietnam, was investigated in comparison with native forest and the same plantations 6 years ago. The author found that the Myriapoda community in replanted forest is very different from the mature forest community in species composition, structure, and abundance, and it has typical features of a soil community in a young, non-stable system. However after comparing the community in replanted forest with the same community 6 years later the author found a progressive dynamic in developing soil community into one similar to a mature forest community.

Keywords: Reforestation, tropical forest, Diplopoda, Chilopoda, soil community.

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