Influences of soil creatures toward aboveground Arthropods in environmentally friendly rice field

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Abstract. Environmentally friendly farming is the most encouraging approach to beat the negative impacts of conventional farming on the ecosystem. To determine the effect of different histories of environmentally friendly rice fields on the interaction between soil creatures and biodiversity of aboveground arthropods, the researchers conducted studies in 5 and 20 years old of environmentally friendly rice fields. The investigation was conducted to find out the impacts of soil creatures on the number of aboveground arthropods by estimating the activity of soil creatures, nutrient contents, and abundance of arthropods. The research was hypothesized that long histories of living matters in the environmentally friendly rice field are supposed to rise soil microbial denitrification and N immobilization, adequately increment the plant N contents and arthropods abundance. The results showed that 20 years of environmentally friendly rice fields improved the abundance of soil creatures, biomass of soil microbial C and N, soil nutrition, and these effects indirectly improved the abundance of aboveground arthropods. This investigation recommends that environmentally friendly rice fields improve the interactions among soil creatures and the aboveground ecological community accordingly may accomplish supportability of the rice field framework.

1. Introduction

Soil organisms performs an important part in agroecosystem. They help the cycling of organic living matter and associated nutrients which will affect soil fertility. They also change the soil structure physically through their movement. Ultimately, the present of soil organisms change the existence and composition of soil nutrients [1-3]. Furthermore, the presence of soil organisms also supports the aboveground communities through the accessible resources they obtain from the plant [4]. The loss in the diversity of soil organisms is likely to bring a negative effect on the agricultural ecosystem. The lack of their profusion will decrease their beneficial functions to their communities and detract their advantageous effects on the environment [5]. Hence, the preservation of soil organism biodiversity is necessary to keep the balance of the ecosystem by preserving the biotic communities in aboveground and belowground ecosystems.

There are several types of relationships between soil organisms and aboveground communities. Their interaction might be useful [6-7] to the agricultural ecosystem. However, Chapman et al. [8] stated that the interaction between soil organism and aboveground communities negatively affect the balance of the agricultural ecosystem. Meanwhile, the null effects of their interaction on the agricultural ecosystem
were also reported [9-10]. Interaction between soil organisms and herbivore populations might occur through the changes of plant growth and nutrition. Bonkowski et al. [6] demonstrated that soil organisms could enhance plant productivity by mineralizing organic matter by producing nutrients including available nitrogen to other trophic levels [11].

Due to the presence of interaction between below and aboveground organisms, there are concerns to investigate the possible effects of soil organism populations towards aboveground communities such as herbivorous and or predator insects [12-14]. Previous studies had examined such interactions separately, i.e., in subterranean ecosystems [15-18] and aboveground ecosystems [19-21]. However, few studies have determined the relation between soil creatures and aboveground ecosystem especially in environmentally friendly rice fields. The study thus aimed for determining the influence of soil creatures towards to population of aboveground arthropods. The observations were performed on the soil creature activity, nutrient contents, and profusion of the aboveground arthropods. We assume that microbial N immobilization and denitrification should be increased by the provision of organic application in the environmentally friendly fields, hence, effectively improve the nitrogen available for aboveground arthropod.

2. Materials and Methods

2.1 Study Area
The researchers experimented with six of 5 and 20 years environmentally friendly rice fields. The environmentally friendly rice fields distributions were between conventionally paddies management, and cultivation without any fertilizers (organic matter and synthetic fertilizer) or agrichemical pesticides. The land was flat and covered roughly 6 km from west to east and 12 – 15 km from south to north and functioned primarily as rice field farming. Most rice fields were conventional farming, and less than 1% were environmentally friendly fields.

2.2 Sampling of Soil Communities
The soil sampling is to determine the composition of the soil creatures in 5 years and 20 years old of environmentally friendly rice fields. At the beginning, we took nine plots of 20 × 20 cm in deep of 20 cm in each area, then, moved the soil samples to the sacks made of plastic and moved them to the laboratory. After that, the soil samples got filtered through a 0.5 mm sieve, while other samples were obtained using cylindrical cores (10 and 15 cm diameter) in nine plots of each field for the assessment of microbial activity and soil nutrients contents. The soil creatures were visually marked and counted. We assessed the nitrogen mineralization (nitrification and ammonification) and carbon mineralization (CO2 net potential output) during 30 days by aerobic incubation. Persulphate digestion determined Microbial Nitrogen and DON (melted organic nitrogen) accompanied by extraction using Chloroform [22]. Inorganic soil nitrogen was built up in 30 mL of 2.0 mol/LKC1 after extraction [23] quantifying soil nutrients contents as far as N and carbon (C) concentration. Air-dry soil was crushed to dust then broken down with a computerized NC corder (Sumika Chemical Analysis Service, Osaka, Japan; Sumigraph NC-220F).

2.3 Arthropods Samplings
We assembled arthropods with a beating system in 9 plots of 50 × 50 cm to 5 and 20 years old of environmentally friendly rice fields. They categorized and counted every specimen into different taxonomy. We collected the bugs and arachnids from the zones depicted and ordered into the littlest conceivable taxonomy utilizing the accessible keys and aides for the taxonomy.

2.4 Statistical Analysis
We conducted the observation with R [24] for Statistical Computing (ver. 3.1.0 for Windows). The impacts of 5 years and 20 years environmentally friendly rice fields on soil creatures and abundance of aboveground arthropods, nitrogen and carbon content in plants and soils, and biomass of rice plant were
investigated using a generalized linear mixed model (GLMM) by applying lme4 package with field as a random effect.

3. Results and Discussion

3.1 Abundance of Soil Organisms
Soil creatures of Diptera larvae and Oligochaeta number were increased in 20 years of environmentally friendly rice fields than 5 year (Figure 1). In this study, we identified the most abundance larvae of Diptera such as Nematocera (df = 1, $\chi^2 = 6.47, p < 0.05$, Figure 1) and Brachycera (df = 1, $\chi^2 = 4.61, p < 0.05$, Figure 1), and Oligochaeta, such as Enchytraeidae sp. (df = 1, $\chi^2 = 10.17, p < 0.01$, Figure 1), and Lumbricidae sp.

![Figure 1](image_url)

**Figure 1.** Effects environmentally friendly rice fields of the numbers of Diptera larvae (a) Oligochaeta (b) in 5 and 20 years of. Significant differences based on GLMM using Poisson error distribution (**p < 0.01, *p < 0.05**).

3.2 Soil Nutrient and Activity Soil Creature
Soil creature biomass C and N were significantly improved in 20 years of environmentally friendly rice fields than 5 years (Biomass C: df = 1, $\chi^2 = 9.41, p < 0.01$; biomass N: df = 1, $\chi^2 = 12.39, p < 0.001$, Figure 2). The histories of environmentally friendly rice fields also influences ammonium and carbon...
decomposition (Ammonium: $df = 1, \chi^2 = 12.29, p < 0.001$; decomposition C: $df = 1, \chi^2 = 6.37, p < 0.05$, Figure 3b-c), while nitrate was similarly on 20 years and 5 years of environmentally friendly rice fields ($df = 1, \chi^2 = 2.86, p = 0.09$, Figure 3a). In addition, 20 years of environmentally friendly rice fields also significantly improved the C/N, N, and C proportions compared to the 5 year environmentally friendly rice fields (concentration: $df = 1, \chi^2 = 10.34, p < 0.01$; C concentration: $df = 1, \chi^2 = 12.48, p < 0.01$; C/N ratio: $df = 1, \chi^2 = 15.11, p < 0.001$, Figure 4).

**Figure 2.** Effects of 5 and 20 years environmentally friendly rice fields on Biomass of microbial carbon (a), Biomass of microbial nitrogen in soil (b). Significant differences based on GLMM using Gaussian error distribution (**p < 0.001, ***p < 0.001).
Figure 3. Effects of 5 and 20 years environmentally friendly rice fields on Nitrates (a) Ammonium (b), and Decomposition of carbon in soil. Significant differences based on GLMM using Gaussian error distribution [***p < 0.001, *p < 0.05, ns (not significant, p ≥ 0.05)].
Figure 4. Effects of 5 and 20 years environmentally friendly rice fields on nitrogen concentration (a) Carbon concentration (b), and C/N ratio (c) in soil. Significant differences based on GLMM with Gaussian error distribution (***p < 0.001, **p < 0.01).

3.3 The Number of Aboveground Arthropods

Aboveground arthropods appeared tended to be higher in the 20 years environmentally friendly rice fields than in the 5 years environmentally friendly rice area (Figure 5). Nevertheless, only the abundance
of Collembola showed significant different between 20 years and 5 years environmentally friendly rice fields (df = 1, $\chi^2 = 7.51$, $p < 0.001$, Figure 5d).

Figure 5. Effects of 5 and 20 years environmentally friendly rice fields on the number of aboveground ecological community of Rice water weevil (a), Spider (b), Thrip (c), Collembolla, Nematocera (e), and Bractycera (f). Significant differences based on GLMM using Poisson error distribution [**p < 0.01, ns (not significant, $p \geq 0.05$)].

The study identified the relationship between the soil creatures and the aboveground arthropods via soil activity in the 20 year environmentally friendly rice fields. The abundance of soil creatures was significantly associated with microbial biomass C (df = 5, $\chi^2 = 3.30$, $p < 0.01$, Figure 6a). Nevertheless,
the aboveground arthropods abundance has a positive correlation with the N concentration of soil \((df = 5, \chi^2 = 6.47, p < 0.05\) Figure 6b).

![Graph showing correlation between soil organism abundance and microbial biomass carbon (p<0.01) (a) and between abundance of arthropods and N concentration of soil (p<0.05) in organic paddy fields (b).](image)

**Figure 6.** Correlation between soil organism abundance and microbial biomass carbon \((p<0.01\) (a) and between abundance of arthropods and N concentration of soil \((p<0.05\) in organic paddy fields (b).

The activity of soil creatures is affected by histories cultivation of environmentally friendly rice fields [25]. The long-term history of application of organic matter in each growth season in environmentally friendly rice fields can improve the carbon availability and influence toward to the abundance of soil creatures [26]. In this study, we found that short history of environmentally friendly rice fields, such as 5 years have a fewer number soil creatures than a long history of environmentally friendly rice fields, such as 20 years. However, based on statistical analysis, abundance of aboveground arthropods mostly showed has not significantly affects on 5 and 20 years of environmentally friendly rice fields, whereas in 20 years was inclined to be has greater aboveground arthropods. This research clarified that the organic matter application in the environmentally friendly rice fields increased the soil creature and soil nutrient content, and toward influence on the number of aboveground arthropods.
Minority studies have performed that growth of plants in environmentally friendly rice soil, which using organic matter application, are less attack from herbivorous insects and pest [11]. This research found the relation between the soil nutrition content of environmentally friendly rice fields and the difference histories on cultivation of environmentally friendly rice fields. The soil creatures and soil nutrients contents were significantly improved in 20 years than 5 years of environmentally friendly rice environmentally friendly rice field, moreover the number of aboveground arthropods was higher also in 20 years than 5 years old of environmentally friendly rice fields. Nevertheless, the aboveground arthropods abundance has a positive correlation with the N concentration of soil in environmentally friendly rice fields. Concept the roles and functions of long term history of environmentally friendly rice farming system, further studies can be conducted to prove the link connection among soil creatures and aboveground arthropods in environmentally friendly rice fields with more increasing the number of parameters for calculating the soil creatures, plant, and aboveground arthropods.

4. Conclusion
The study concluded that 20 years of environmentally friendly rice fields improved the abundance of soil creatures, biomass of soil microbial carbon and nitrogen, soil nutrition, and these influences indirectly improved the abundance of aboveground arthropods. This investigation recommends that long history of environmentally friendly rice fields improve the interactions among soil creatures and the aboveground ecological community accordingly may accomplish supportability of the rice field framework.

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