Research article

One Way of Expressing Bio-diversity based on Simpson and Fisher Indexes

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Abstract For making out soil lives in upland field and field properties clearly, micro-arthropods living in farmland soils were picked up, and population, genera, diversity index of Simpson (1/λ) and that of Fisher (α+1) were employed for evaluating soil micro-arthropods under different management were investigated in this study. Also soil physical and chemical properties were measured. Soil samples were gathered from the fields at Hachioji, Tama and Machida in Tokyo, Japan. Planting and fertilized types were collected. And for making out of relationships in diversity of soil micro-arthropods and soil moisture conditions, soil micro-arthropods in some types of drip irrigation fields and tube irrigation fields in green house were observed. The fields in this study were categorized into two groups based on the history of dressing or land degradation. There was no certain difference in population, number of genera and two types of diversity indices between decollated and not-decollated fields. Fisher's diversity index seemed to be larger than Simpson's in soil dressed fields, while Simpson's diversity index seemed to be larger than Fisher's in non-dressed fields. The difference in types of diversity may be caused by years of cultivation in those fields. Also, based on the results of multiple regression analysis, population, number of genera and Simpson's diversity index were related with macro porosity. So, it was concluded that those two types of diversity indices are useful for making clear difference of bio-diversities in upland field's soils.

Keywords soil micro arthropods, bio-diversities, soil physical property

INTRODUCTION

Bio-diversities in farmlands are important for sustainable land use. Soil conditions in agricultural fields are hard for lives. That limits richness of lives of soils. And low application of organic fertilizers caused declining the richness of soil lives is said. But in Japan, ecosystems in upland fields were less interested than that in paddy fields. So there are few surveys on upland field's bio-diversity and its effects on their soils in Japan. One cause is that farmers avoid their fields disturbing many places for research, especially in farming season. It is need that solve that problem will be solved for evaluating farming fields in biological diversity.

Micro-arthropods are kinds of group of soil lives, sort of insects and mites. And micro-arthropods are known to have large population and high species richness, especially in high content of organic matters. That fits 'good' soil. Effects of their density or species richness on soil chemical properties were investigated in Europe (Cole et al., 2004). Enough population is need for evaluating bio-diversity, so there is some possibility of evaluating farmland with bio-diversity disturbing minimum space.

OBJECTIVES

Surveys on upland field's micro-arthropods in Japan were mainly in just biological. Cropping or harvesting methods in their surveys were limited 2 or 3 types, and soil physical properties were not discussed. So making out some relationship between upland field's micro-arthropods diversity and its soils, and suggesting method of the evaluating the farming fields with the biological diversity are objectives in this study.

METHODOLOGY

Field survey

Soil samples were gathered from the farmers' fields at Hachioji, Tama and Machida in Tokyo, Japan. The fields were located in west hill side of Tokyo, there are called Tama hills. There are mixed residential area and farm fields. Some of farm fields were dressing or land degradation for making residential area. So the fields in this study were categorized into two groups based on dressing or land degradation affected or not. We use "decollated fields" for the fields that dressing or land degradation affected in this study.

Soil sampling carried out Aug. 2003 to Nov. 2003 and Aug. 2005 to Nov. 2005. Autumn is the season that micro-arthropods' population is the most. All of the fields were for vegetables, but a few sampling had the same plant. Fertilizing is independent in each field. And no herbicides nor pesticides were used. 5 cm depth, total 400 ml surface soil was sampled for gathering soil micro-arthropods. Physical properties of soils and amounts of fertilizers were collected. Total 22 fields' samples were measured.

Experimental survey

For making out of relationships in diversity of soil micro-arthropods and soil moisture conditions, soil micro-arthropods in some types of drip irrigation fields and tube irrigation fields in green house were observed. Drip irrigation plots were typed with water mass (standard, less and little), and interval were 2 or 3 days, irrigated 3-5 mm/day in standard plot. Less irrigation plot was 0.75 times, little irrigation plot was 0.5 times less than the standard plot. Tube irrigation field was there were micro-pored tube on the ground base with minimum pressured and irrigated full of soil water pore volume within the plant growth. Soil sampling carried out Jun. 2006 to Oct. 2006. 5 cm depth (same as field survey), 200ml soil was sampled from each plots in each 2 weeks within irrigating for plants.

This green house is built in Setagaya, Tokyo, about 20 km far from field survey area. And soil category of this field is same as decollated fields in field survey. The green house of this survey was also used test at supplying gathered rain water falling on top of green house. So the tanked rain water was used for irrigation in this survey.

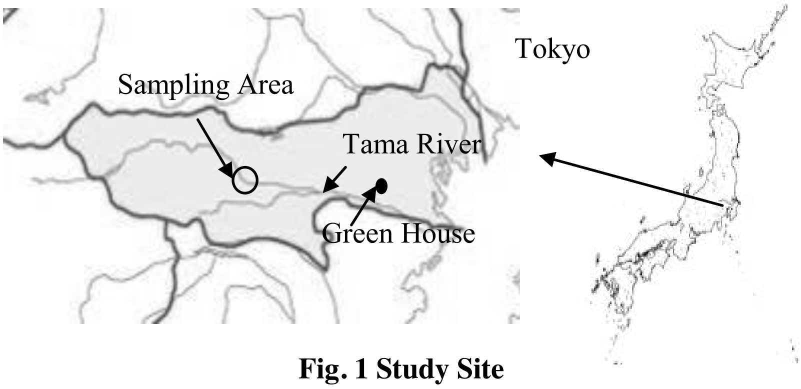

Fig. 1 Study Site

Gathering soil micro-arthropods

Micro-Arthropods in this study are mainly in collembola and mites. They are called soil animals or soil meso-fauna in Japan (Fig.2). Soil macro-fauna are larger than 2 mm, include earth worms and insects. Soil micro-fauna are smaller than 0.2 mm, lives in soil water.

Tullgren's apparatuses (Fig. 3) were used for gathering soil fauna. Apparatus was made from 2 mm opening sieve, stain-less funnel and 40 W heating light stand. Soil samples for investigating micro-arthropods were put on stainless sieve set on funnel under the heating light for 48 hours. Glass beaker with 70% alcohol was set for catching arthropods dropped through funnels. Then micro-arthropods were classified into genera, and then each species' population was counted with a microscope. Pictorial Keys to Soil Animals of Japan (Edited by Aoki, 1999) was used for classifying.

Fig.2 Soil micro-arthropods

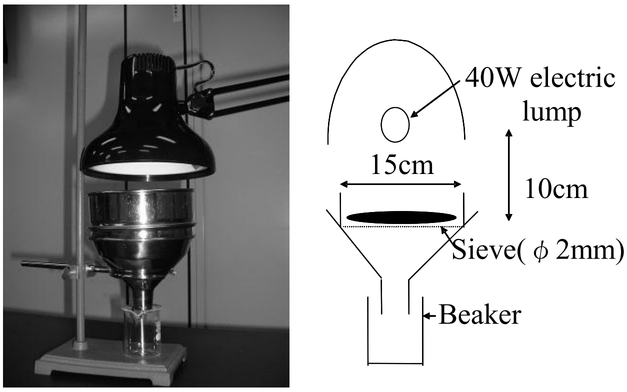

Fig.3 Tullgren's apparatuses

Diversity indices

If their species' richness (one of the diversity index) was discussed, it is not compared in other situation. Because of the environment of every field is different. It needs some standard that the bio-diversity can use evaluation of farming fields.

Two types of diversity indexes were employed for evaluating soil micro-arthropods under different management were investigated in this study. Fisher et al. (1943) suggested that some of number of species and number of individuals in random sample fitting logarithmic distribution. α is fixed and calculated from Eq. (1) as uses total population (N) and total species (S). Simpson suggested λ as the index which independent of sample size (Simpson, 1949). λ is calculated in Eq.(2). Simpson also said, we obtain Eq. (3) when the individuals of population are under the logarithmic population. This is the point that the Fisher's diversity index (α+1) is the expectation of the Simpson's diversity index (1/λ) at the identified total population (N) and total species (S). An expectation can use the one kind of standard. So 1/λ and α+1 are used as diversity index in this study.

$$S = \alpha(\ln N/\alpha + 1) \tag{1}$$

$$\lambda = \frac{\Sigma Ni(Ni-1)}{N(N-1)} \tag{2}$$

$$1/\lambda = \alpha + 1 \tag{3}$$

RESULTS AND DISCUSSION

Field survey

Population, number of genera and two types of diversity indices are shown in Table 1. Total population and total genera in non-decollated fields were larger than those in decollated fields. It would depend on the difference of land use around the sampling fields. There are many houses and asphalt pavement roads around the decollated fields, and woods and bamboo forest around non-decollated field. But there was no certain difference in population, number of genera and two types of diversity indices between decollated and not-decollated fields. those are suggests that the severe impact for soil micro-arthropods from farming activity (cultivating, tillage, weed control, etc.) .

But in relationships between two types of diversity indices (Fig. 4), Fisher's diversity index seemed to be larger than Simpson's in soil decollated fields, while Simpson's diversity index seemed to be larger than Fisher's in non-decollated fields. The difference in types of diversity may be caused by years of cultivation in those fields.

Based on the results of multiple regression analysis (Table 2), population, number of genera and Simpson's diversity index were related with macro porosity (d > 0.3mm, measured water suction by 10 cm high capillary rise) and water content (dry base) at the sampling day. The macro porosity was almost same space as air phase 6-12 hour after rain or irrigation. That air space in soils limits the micro-arthropods' population.

Experimental survey

Results of averages and medians of population, genera and two types of diversity indices in each sampling in experimental survey are shown in Table 3. Tube irrigation plot had the least population and number of genera. Those results can be express as same as in field survey, the air phase in tube irrigation plot was lowest in experimental survey. But there was no certain difference in population, number of genera and two types of diversity indices between each plot.

But in relationships between two types of diversity indices (Fig. 5), both standard irrigated plot in drip irrigation and underground water irrigation plot were stable conditions of diversity indices. Because standard irrigated plot was the most stable soil moisture conditions in drip irrigated fields, there were same tendency that both standard irrigation plot and tube irrigation had similar expanse of the distribution. And high correlation coefficient of tube irrigation plot was caused by stabilized soil moisture in their field. This result suggests that soil moisture condition is the most important factor for sampling times minimized.

Table 1 Population, number of genera and two types of diversity indices in field survey

Decollated fields					Non-Decollated fields				
No.	Pop.	Gen.	$1/\lambda$	α+1	No.	Pop.	Gen.	$1/\lambda$	α+1
No.1	6	5	15.0	15.1	No.12	52	18	11.5	10.8
No.2	82	18	10.6	8.1	No.13	360	15	1.3	4.2
No.3	235	24	8.5	7.7	No.14	53	16	8.2	8.8
No.4	100	12	5.5	4.6	No.15	369	21	4.1	5.8
No.5	53	15	11.9	8.0	No.16	281	29	3.8	9.1
No.6	67	16	5.0	7.7	No.17	211	13	3.2	4.1
No.7	88	18	7.3	7.8	No.18	43	12	8.9	6.5
No.8	12	6	6.6	5.8	No.19	65	15	5.2	7.1
No.9	170	19	6.7	6.5	No.20	10	4	2.1	3.5
No.10	135	14	5.2	4.9	No.21	77	23	11.7	12.1
No.11	205	11	2.4	3.5	No.22	135	13	3.3	4.5
Ave.	104.8	14.4	7.7	7.2	Ave.	150.5	16.3	5.8	7.0
Med.	88.0	15.0	6.7	7.7	Med.	77.0	15.0	4.1	6.5
Total	1153	46	11.4	10.6	Total	1656	53	5.9	11.5

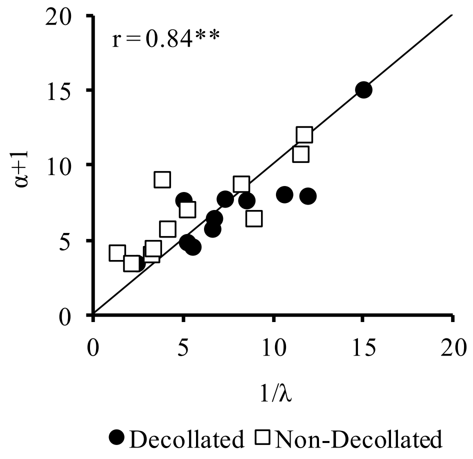

Fig. 4 Relationship between two types of diversity indexes in decollated and non-decollated fields

Table 2 Results of multiple regression analysis between bio-indexes and soil physical properties in field survey

Criterion variable	Predictor variable	Partial regression coefficient	F factor	Partial correlation coefficient	Correlation coefficient	Multiple correlation coefficient
Population* (log)	Macro porosity*	0.588	8.481	0.589	0.391	0.597
	Water content*	0.561	7.719	0.570	0.354	
Genera*	Water content**	0.685	11.334	0.644	0.568	0.589
	Macro porosity	0.332	2.669	0.378	0.091	
1/λ	Macro porosity	-0.431	3.870	-0.431	-0.431	0.371
α+1	-	-	-	-	-	-

* $p<0.05$, ** $p<0.01$

Table 3 Results of averages and medians of population, genera and two types of diversity indexes in each sampling in experimental survey

		Drip irrigation field			Tube irrigation field
		Standard (×1.0)	Little (×0.75)	Less (×0.5)	
Population	Average	41.9	41.2	35.1	26.3
	S.D.	28.7	28.2	27.3	18.7
	Median	44	34	26	19
Genera	Average	7.3	8.6	9.1	7.3
	S.D.	3.2	3.3	3.3	4.2
	Median	8	9	9	6
1/λ	Average	4.1	5.4	6.5	4.4
	S.D.	1.4	3.1	2.9	1.4
	Median	4	4.6	7.2	4.35
α+1	Average	4	5.1	5.8	4.8
	S.D.	1.0	2.4	1.7	1.7
	Median	4.2	4.3	5.9	4.95

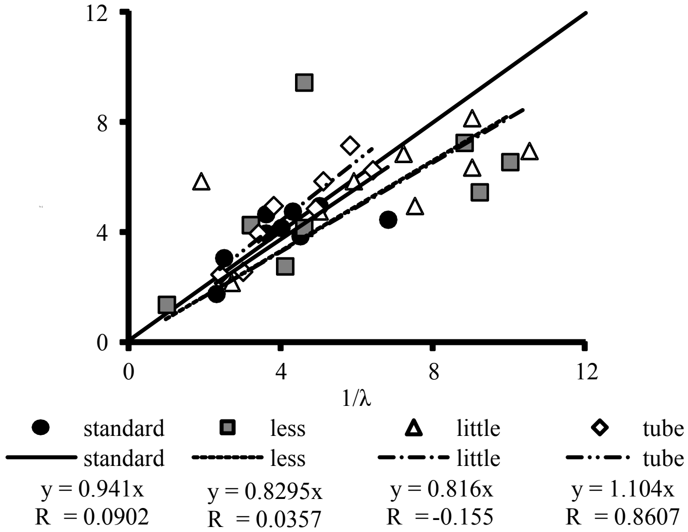

Fig. 5 Relationship between two types of diversity indexes in irrigated plot

CONCLUSION

Using Fisher's diversity index as the expectation of Simpson's diversity index, it makes clearly that the difference in types of diversity may be caused by years of cultivation in those fields. Field survey shows that the soil macro porosity (sometimes same as gas phase) is important for soil micro-arthropods. And through the field survey and the experimental survey, soil moisture condition is most important factor for soil sampling minimum.

So we concluded that those two types of diversity indexes are useful for making clear difference of bio-diversities in upland fields soils.

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