Effects of Satoyama Restration on Pollination System in Terraced Paddies in Kanazawa

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Introduction

Satoyama is the way [a]Japanese manage an area with limited resources with high efficiency. S*atoyama* areas make up as much as 40% of national land of Japan, and account for about half of the sites where many endangered species are found. However, since 1960's *satoyama* areas have been decreasing rapidly which raised a serious problem in biodiversity. Fortunately, in recent years, there has been increase of interest in importance of Satoyama. Restoration of abandoned Satoyama, together with monitoring of change in biodiversity, has been started in Japan and also in other countries, e.g. Russia and Korea. For understanding the Satoyama ecosystem, monitoring the biodiversity change in the restoration system is crucial. There have been several studies on biological interaction in Satoyama system (Kato 2001). However, change in of pollination system during restoration of Satoyama has rarely been studied yet.

Materials and methods

To determine the effect of *satoyama* restoration to pollination ecology of local community, we made observations for flowering plant and flower-visiting insects. In this study, regular census was carried out, in the major habitat mosaics, once or twice a week along census route marked with poles at 5 meters interval (one section) from June to October in 2003 and from March to October in 2004 and 2005. Observations were made during the middle of the day 1000-1500 h.

We recorded the flowering size and blooming flower species. In the same time we also recorded visited flower species and time of visitation, whether the stigma and/or anther were contacted and whether the insects were collecting pollen and/or nectar from particular plant species. In order to further identification of insects we collected all flower-visiting insects using sweeping net.

Result

Flowering Plant

Annual flowering data (the means for 3 years: 2003 to 2005) are given in Table 1. Analysis was confined to the diversity index of flower. Total flowering size (number of flowers for one year) was fluctuation among years of observation. However, the diversity of flowering plant species was significantly increase based on the real number of total flowering species and diversity index (ANOVA, $P<0.05$) (Table 1). Our observation also found that the dominance index of blooming flower was also significantly increase among years (ANOVA, $P<0.05$) (Table 1).

Table 1 Total numbers of flowers and flowering plant species and the indexes of diversity and dominance in flowering plant community at the study sites

	2003	2004	2005
Total flowering size	29,6940	432,107	214,733
Total flowering species	65	94	101
Diversity index	0.61	0.77	0.90
Dominance index	0.61	0.71	0.81

Flower-visiting insect

Most flower-visiting insects were belonging to Diptera order followed by order Hymenoptera. Both order formed 90% of flower-visiting insect composition.

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Table 2 Total numbers of visited plant species and flower-visiting insects and relative abundance of each taxon of flower-visiting insects at the study sites

	2003	2004	2005
Visited plant species	45	63	66
Total visiting frequencies	986	848	781
Diptera	53.04%	58.50%	52.11%
Hymenoptera	40.67%	37.74%	43.02%
Coleoptera	2.54%	1.18%	4.35%
Lepidoptera	1.72%	1.88%	0.25%
Hemiptera	1.92%	0.59%	0.13%

Discussion

The number of flowering size and diversity of flowering plant was highly increase in the study area could be caused by restoration work. Removal of highly competitive species, increasing amount of sunlight and altering habitat condition created intermediate disturbances which could influence resources availability. Resources availability such as water, nutrients, and light can influences pollinator-mediated selection on floral traits such as length of flowering period, date of first flower, and total number of flower (Totland, 2001; Caruso et.al., 2005). Change in these floral traits of some particular expansive species could benefit less-expansive plant species as there were new available niche to exploit. Our analysis on spatial distribution using Simpson's Dominance Index also showed significant increased during observation period which could be caused by domination reduction of some particular flowering plant species.

There were increased in total number of flowering plant species visited by insects. As the number of flower diversity increased insects had more choice for resources. Our study also showed that late flowering species had higher visitation frequencies that early-flowering species, a result consistent with some earlier studies (Thompson, 1982; McCall and Primack, 1992; Hegland and Totland, 2005). There are two interpretation of this pattern. First, the number of potential pollinator species and their abundance will normally increase throughout the season. Second, the number of insect-pollinated species in bloom increased during the flowering season at our study site (Putra and Nakamura, unpublished). As a consequence, there is no or less competition for pollinator attraction among plant species, thus there is higher visitation to species flowering simultaneously late in the season. Feinsinger (1987) argued that facilitation for pollinator visitation among plants by co-flowering could be as least as important as competition resulting in divergent flowering.

Our study also showed that most of flower-visiting insects were belonging to Diptera. This could be explained as most of blooming flower species in our study site were open flowers, a pattern consistent with the fly-pollination syndrome (Feagri and van der Pijl 1979; Hegland and Totland, 2005).

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