Effects of environmentally friendly farming and multi-scale environmental factors on generalist predators in rice paddy ecosystems of Japan

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1. Introduction

Generalist predators such as spiders and ground beetles provide important ecosystem services by suppressing density of pest insects in agroecosystems, which offers a sustainable solution to trade-off between agricultural production and biodiversity conservation. There is increasing recognition that landscape factors beyond field-plot scale are important determinants for community structure of generalist predator as well as within-farmland practice, because surrounding environments serve as alternative habitats for them during time when arable fields are ill-suited [1]. Additionally, macro-scale factors such as climate and topography are beginning to receive much attention as important drivers for farmland biodiversity at a large spatial-scale [2]. Based on these backgrounds, many studies have been conducted to explore how the multi-scale factors determine abundance and diversity of generalist predators in upland farmlands (e.g. wheat fields and meadows) around European countries, but very few studies have been carried out in rice paddy fields which are among the major types of farmland in Asian countries. Here, I will present some of the results of the research projects which explored how agricultural practice and environmental factors influence generalist predators in rice paddy ecosystems of Japan.

2. Environmentally friendly farming

Environmentally friendly farming practice, which includes the reduction or omission of chemical pesticides and chemical fertilizers, is known as an effective way to enhance the numbers of generalist predators [3][4]. To test this positive effect of farming practice in rice paddy ecosystem, abundances of various generalist predator groups were assessed in conventional and environmentally friendly paddy fields (with no insecticide) in several sites in the northern part of Kanto region, Japan. The results showed that environmentally friendly farming significantly enhanced the numbers of various taxa such as spider, dragonfly and frog. This may be attributed to improvement in survival rates of predators and/or increases in alternative prey availability due to no use of pesticides [5].

3. Landscape factors

To reveal the effect of landscape context on generalist predators in rice paddy fields, I and my colleagues surveyed the abundance of spider, dragonfly and frog in conventional and environmentally friendly rice paddy fields along a land-use gradient from simple arable-dominated to forest-rich landscapes in the northern part of Kanto region. To evaluate the areas of land use categories, we generated different sized-buffer zone (50-200 m) around a focal rice field with GIS, and calculated land use categories (forest and building) in each buffer zone. The effects of landscape and farming practice on predators were analyzed using the generalized linear model (GLM). Results showed that generalist predators showed differential responses to farming practice and landscape context depending on taxonomic group. Two major spider groups, *Tetragnatha* and lycosid spiders positively responded to increase in forest area within a 200 m around the study fields and environmentally friendly farming. Two frog species exhibited different responses to local and landscape factors, reflecting differences in their habitat use. For example, daruma pond frog *Pelophylax porosus*, which depended on wet habitats, was negatively influenced by forest areas within a 100m around the study fields and positively by environmentally friendly farming. In contrast, Japanese brown frog *Rana japonica*, which inhabited forest area in non-bleeding season, increased with forest area within a 200m around the paddy fields. The *Sympetrum* dragonflies were positively affected by environmentally friendly farming, but not by landscape factors, because their effective spatial scale seems to be broader than 200 m reflecting their high dispersal ability. Our findings suggest the effects of landscape context are highly variable depending on species properties, even within the same taxonomic group.

4. Macro-scale factors

Topography and climatic variables are the key drivers of biodiversity dynamics at large-spatial scale. To explore the effects of the macro-scale factors on generalist predators within farmland, we revealed the nation-wide patterns of abundance and species composition of two major spider groups, *Tetragnatha* and lycosid spiders, using the data obtained from 15 regions across Japan, ranged from the south part of Kyushu to the north part of Honshu. Results showed that the abundance of *Tetragnatha* spiders was likely to increase at high latitudes. A hierarchical liner model including multi-scale factors showed significant interacting effect between agricultural practice and precipitation on *Tetragnatha* spiders, indicating that the positive effect of environmentally friendly farming on spider abundance was enhanced in the area with high precipitation [2]. In contrast, no latitudinal trend was found in the numbers of lycosid spiders. Species composition of *Tetragnatha* spiders with total 6 species differed among the regions: species diversity index increased with latitudes, which contrasted with a general trend of decreasing biodiversity from warm-temperate towards cold regions. In contrast, two major lycosid species showed an exclusive distribution along latitude: *Pardosa pseudoannulata* was abundant in the south-west part of Japan, whereas *Pirata subpiraticus* was prominent in the north-east part. This pattern may reflect differences in their preferable climate zones, but competitive interaction seems partly involved in determining their distributional boundary. These results suggest that the macro-scale factors are important determinants for local community structure of generalist predators.

5. Conclusion

Our study demonstrates that the multi-scale factors are the key drivers of generalist predator community in rice paddy ecosystems. Future studies should aim to explore the underlying mechanism behind the patterns of abundance and diversity of the predators, and clarify the relationships between their community properties and ecosystem services for pest control.

References

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