Integrated Biodiversity Management (IBM) in Rice Paddies

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Progress from Plant Protection to Integrated Pest Management (IPM)

Reviewing the history of pest management in Japan, it was the age of so-called “plant protection” until 1945, when there was no effective pest management measures. Thus, dragonflies and fireflies were quite commonly found growing in rice paddies. The giant water bug~~s~~, the rare species today, used to be regarded as a serious insect pest of fish farms. Biodiversity was, although unintentionally, protected at that time. After the World War II, it was the age of pesticide sterilization when synthetic pesticides became available and the prevailing idea was to defy all living organisms except crop plants. The consequence was development of pesticide resistance of insects, pesticide residues in food and environment, resurgence of potential insect pests as real pests, and sharp decrease of such “neutral insects(Tada-no-mushi)” as fireflies, and natural enemies of insect pests

The rice stem borer was the most serious insect pest in Japan, and BHC was the key insecticide to control the borer. At the same time, the green rice leafhopper which transmits the rice dwarf disease had begun to spread. As granular formation of BHC was developed as an alternative of dust formulation in around 1960, it was believed that BHC no longer affected spiders and other non-target insects because dissolved BHC would be absorbed by rice plants and selectively kill ~~Asiatic~~ rice stem borers that lives inside the stalk. Even when a conventional dosage (6 kg/10a) of BHC granules was applied, a wolf spider dies if it was fed with green rice leafhoppers that had sucked the BHC contaminated rice plants. Even after three weeks of application leafhoppers had contained enough BHC to kill these spiders. But the BHC-tolerant leafhoppers apparently looked intact. This study had led to a ban of chlorinated pesticides in Kochi prefecture in 1969 (nationally 1971). This was the first step to the integrated pest management (IPM) in Japan.

Even if an immortal insect pest comes into existence under a heavy pesticide use, there would be no virtual damage if its population density can be maintained low. To do that it is necessary to replace chemical oriented management with IPM, which utilizes natural controls such as natural enemies and pest-resistant crop varieties, uses a minimum amount of the specific pesticides that less affect natural enemies and non-target organisms, and keeps a low population density of insect pest by an integrated use of available measures.

There are some points in IPM that need to be reviewed. Although the definition of IPM puts emphasis on the control of pest density below the level that causes no economical damage, the actual was the tactic~~al~~ IPM that focuses on the control of pest density under an economic injury level to avoid damages in individual fields, and lacked the view of strategic IPM that maintains the pest density below the economic injury level for a long term and area-wide as well. In addition, the IPM had low interest in “neutral insects (Tada-no-mushi)” since it puts emphasis on economic efficiency of the control of key pests. Once a species is labeled as the pest, they do not have interest even if the species goes extinct. We need to break away from the tactic~~al~~ IPM that aims to control pest in the unit of individual field and promote the strategic IPM that aims to control pest in a broader and longer scale. This is the foundation of the Integrated Biodiversity Management (IBM) that is described next.

“Neutral Insects” (Tada-no-mushi)

Agriculture was viewed as one of the strongest causes destroying nature. However, it turned out that there were a lot of endangered species, including “neutral insects”, living in satoyama. I examined the name recognition of “neutral insect” by comparing the number of hits for this word on the internet in February 2012 with that in January 2009. As a result, the number of hits for “insect” was 50.2 million hits (3.7 times higher than in Jan. 2009), “insect pest” 19.9 million (4 times higher), “beneficial insect” 1.43 million ~~hits~~ (8.4 times higher), and “neutral insect” 14.2 million (1420 times higher). “Neutral insect” is rapidly being adopted in research. Of total 5668 species listed in “A comprehensive list of organisms associated with paddy ecosystems in Japan”(Kiritani ed. 2010) 1867 species are insects and spiders in rice paddy ecosystem. Among them, 177 species are insect pest, 155 are beneficial species. Thus, 1535 species, 82.2%, belong to “neutral species”. They are just the species that are not classified as insect pest and beneficial insects, not meaningless species. We just do not know their roles in ecosystems.

IPM to IBM

Insects in rice paddy consist of residential species (including rice stem borer, ~~pond~~ wolf spiders), migratory species (including planthoppers, linyphid spiders), and aquatic species (giant water bug, dragonflies). Now that most of natural wetlands are lost, rice paddies play a role as their substitute. About one third of rice paddies were wet paddies before the World War II, but most of them had been converted to dry paddies in order to increase rice productivity. Conservation of biodiversity in rice paddy would require a management system of paddy field, water channel, pond, ridge, idle field, surrounding farmland, forests, and to maintain abundance of all arthropod ~~insect~~ species within the suitable range (between extinction threshold and economic injury level) (Figs. 1 and 2).

IBM: Coexistence with all living organisms

We must consider the agriculture “coexisting” with living organisms in farmlands. There is a high demand for food safety. Safety, however, should not be only for consumers. Safety for farmers, as well as many living organisms in farmlands, is desired. An outbreak of insect pest is just a response to the environment created in a farmland. If we can control the abundance of insect pests at normal level as “neutral insects”, the amount of pesticide use would be minimum and arm race between pesticide and insect pests would be avoided. Such an agricultural ecosystem should be a sustainable agriculture that is passed down the generations. That is the integrated biodiversity management (IBM). This is to control the density of pest insect at the level between economic injury level and extinction threshold (Fig. 1).

The arthropods inhabiting paddies require various patches for the completion of their life cycles. The relative importance of IPM and conservation changes along a continuum away from the paddy field, through ridge, water channel, pond, and secondary forest (Fig. 2). The two lines cross at a point most appropriate for a specific location as well as the target species concerned. IBM is still new born. Coexistence with all living organisms would lead to a real safety and sustainable food production.

Fig. 1. Relationship of IPM and conservation/protection in IBM (time axis)

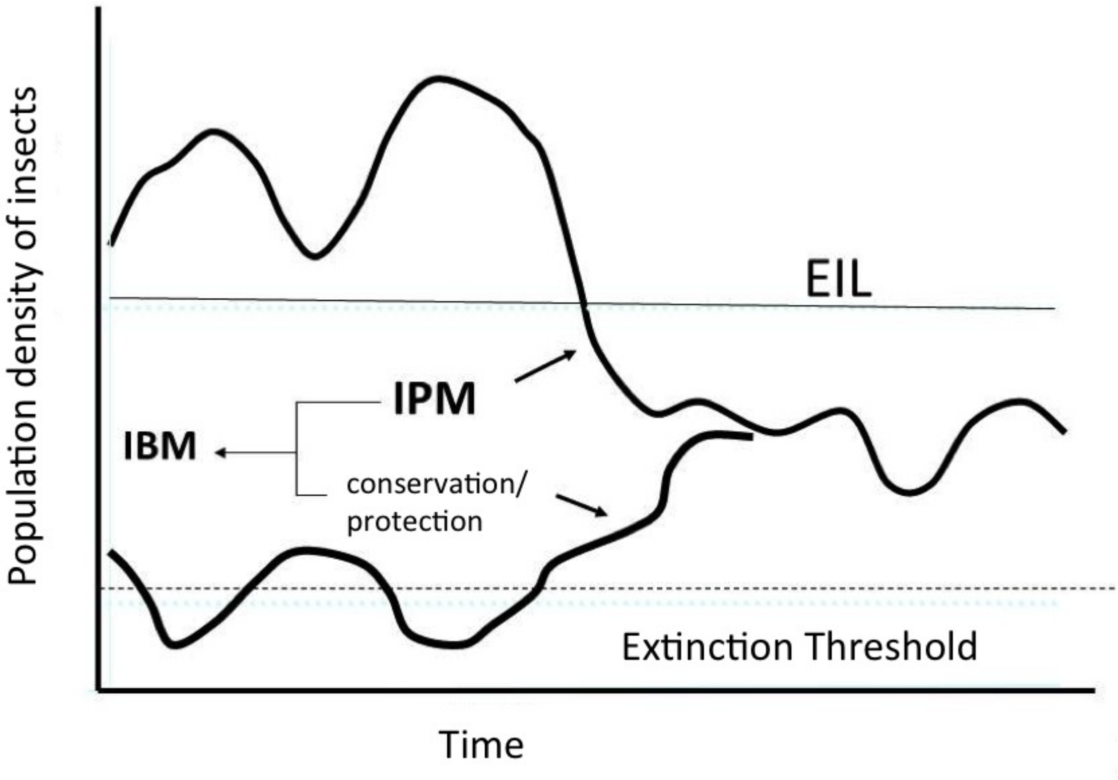

Fig. 2. Relationship of IPM and Conservation/Protection in IBM（Space Scale)