Selection of indicator organisms for functional agrobiodiversity at the crop field level in Japan

1. Outline of the project; Selection of functional biodiversity indicators and development of the assessment methods

2. Selected candidate indicators

3. Utilization of indicators

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A background of stating the project

**Agriculture**
- Rural area is large parts in Japan
- Agricultural area occupy an important position in the natural land.

**Biodiversity**
- Native organisms consists of more than 200 million spp.
- Sustainable use and preservation of biodiversity is required.

**Influence of agriculture**
- Biodiversity preservation through irrigated paddies etc.
- Improper use of pesticides and fertilizers

Achieves sustainable agriculture by using natural enemies of pests and other methods

Functional Biodiversity (FBD) can be used as natural enemies of pests

How to evaluate the agricultural practices?

Quantitative assessment methods are required in monsoon Asia
Structure and goal of the project

Selection of Functional Biodiversity Indicators and Development of Assessment Methods

1. Selection of indicators for the evaluation
   - (1) Field unit (orchard, vegetable field, tea field, soy bean field)
   - (2) Landscape unit (mainly paddy area)

2. Development of simplified monitoring methods
   - Development of sex pheromones of the indicators etc.

Easy-to-understand indicators

Measuring the spread of environment-friendly agriculture, IPM, etc.

Practical assessment methods

Proposing manuals for various regions

Understanding and forecasting biodiversity in Japan

Forecast for conservation and sustainable use of biodiversity

Achieve a balance between productivity and biodiversity for development of sustainable agriculture
Important notices for developing FBD indicators

1 Characteristics of biodiversity in Japan

(1) Localization
- The islands of Japan extend over a long distance in a north–south direction and are situated within various climatic zones. The country has a wide range of fauna and flora.

(2) Various landscape and land use; in 40% rural areas
- Uplands, plains, seashores etc.
- Small mosaic distribution of paddies, upland-fields, forestry, rivers, ponds, etc.

2 Characteristics of insects inhabitancy

(1) Insect abundance
- It depends on various crops and agricultural methods (eg. Intensive or extensive, input of pesticides, chemicals)

(2) Migration
- Several insects migrate in a wider area for overwinter, feeding, and reproduction.

- Indicators should be developed in each region and landscape
- Indicators should be developed at field and landscape units, respectively
Since The islands of Japan extend over a long distance in a north–south direction, and are situated within various climatic zones we established 8 regions to select indicators for each region.

Experimental surveys have been carried out at totally 274 sites, where cover major districts of each crops.

Totally approximately 6,576 surveys have been done in the study, with twice per month on average at each site. This is the first research project using such a large scale of the surveys.
Rules and plan of the research project

**Basic rules**

1. **Goal**
   Development of functional biodiversity indicators and of assessment methods for evaluating environmental-friendly agricultural practices

2. **Candidate indicators (Objective organisms)**
   - Quantitatively measurable
   - Beneficial for agricultural production, such as native natural enemies.
   - Organisms indirectly reflect the presence of organisms that are beneficial for agricultural production.
     (ex. Chironomidae → food of spiders, Attractive plants → Den of Orius spp.)
   - Easy to understand species by instructors and farmers.

**Plans**

1. **The first 2 years (2008-2009)**
   - Selection of indicator candidates involving with good agricultural practices at field and landscape units, respectively

2. **The second 3 years (2010-2012)**
   - Determination of indicators among candidates which could be actually understood by instructors and farmers.
   - Making guideline on evaluation methods of the indicators (how to monitor and conserve indicators)
The surveys were conducted in the country’s major production regions for each crop type.
Basic surveying methods

**Pitfall trap**
- For collecting ground-dwelling arthropods
  - Ground beetles, Spiders, etc

**Yellow sticky trap**
- For capturing flying and plant wandering arthropods
  - Parasitoid wasps, Ladybeetles, etc

**Beating and Sweeping**
- For collecting arthropods on plants or surrounding the fields
  - Spiders, Hovering flies, etc

**Visually observation**
- Counting arthropods on the plant
  - Spiders with web, Ladybeetles, parasitoid wasps, etc
Example of the study

1) ex. Green onion field

- Reduction of chemical application
- Surrounded with banker plant, sorgum
- Wheat was planted between ridges

![Traps and graphs showing comparison between environmentally friendly and conventional fields]
Creating a list of organisms in all study areas

First screening
Selecting organisms **significantly more abundant in environment-friendly fields** than in the conventional fields using statistical tests

Second screening
Considering the **suitability of each organism** as indicators (e.g., benefit for agriculture and commonness in each habitat)

Candidate indicators

More than two million individuals were captured in all the study areas.

A total of 423 organisms were listed as potential indicators including several taxonomic levels (e.g., species, genera, family).

Nationwide- and regional-common organisms were selected as candidate indicators.
**Candidate indicators**

**Nationwide-common indicators**

- *Tetragnatha spp.* ([*Tetragnatha caudicula*] (wandering spider))
- *Pardosa pseudoannulata* (ground-dwelling beetle (carabid))
- *Chlaenius micans* (ground-dwelling beetle, spiders)

**Regional-common indicators**

- **Chubu**
  - Parasitoid wasps, Ants, Predatory mites
- **Chugoku/Shikoku**
  - Parasitoid wasps, Ants
- **Kyushu**
  - Predatory stinkbugs
- **Kanto**
  - Parasitoid wasps, Predatory lady beetles, Staphylinid beetles
- **Northern Japan**
  - Parasitoid wasps, Predatory lady beetles, Predatory stinkbugs, Hoverflies

**Map of Japan**

- **Kinki**
  - Parasitoid wasps, Predatory stinkbugs, Staphylinid beetles, Hoverflies
- **Chubu**
  - Parasitoid wasps, Ants, Predatory mites
- **Chugoku/Shikoku**
  - Parasitoid wasps, Ants
- **Kyushu**
  - Predatory stinkbugs
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**Legend**

- Paddy area (landscape scale)
- Citrus
- Cabbage
- Apple
- Egg plant
- Peach
- Green onion
- Pear
- Tea
- Soybean
From the third year of our project

1. Confirming whether the selected candidate organisms are suitable indicator organisms
2. Developing simple and efficient techniques to survey indicator organisms and standard methods to evaluate the accomplishment of environment-friendly agriculture using the indicator organisms

Establishment of the manual for evaluating environment-friendly agriculture using indicator organisms
Utilization of indicators

For widely spreading environment-friendly agriculture in Japan, indicators should be used.

1. The population level of indicators could be used to assess the environmental impact of environment friendly farming such as IPM practice. Farmers could check the abundance of indicators in their fields and adjust their farming accordingly.

2. The indicators are natural enemies that control crop pests. When indicators are abundant, farmers can leave pest control to the natural enemies.

3. The indicators could be incorporated into the Pest Forecasting Program, a national program of the Ministry of Agriculture, Forestry, and Fisheries.
Indicators could be applied in IPM practice

**IPM practice**

**Prevention**
- Remove diseased or injured plants
- Prevent spreading disease
- Use natural enemies

**Observation**
- Monitoring insects, disease, weeds
- The Pest Forecasting Program

**Intervention**
- Control with various methods such as biological control, physiological control, chemical control, etc.

- Excess acceptable pest level

**Abundances of indicators could be reflected for adjustment of better IPM farming**

**Environment-friendly farming would be distributed widely**