Positive and negative relationships between agricultural activities and biodiversity in rice paddy landscapes of Japan

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CBD-COP10 was held in Japan, Oct. 2010.

Three objectives of CBD

1) Conservation of biological diversity
2) Sustainable use of its components
3) Fair and equitable sharing of the benefits (ABS)

Aichi Biodiversity Target (The Strategic Plan)

Strategic goal B:
Reduce the direct pressures and promote sustainable use.

Target 7: By 2020 areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.
Crises of Biodiversity in Japan

Crises of Biodiversity (The National Biodiversity Strategy 2010)

1. Increase of Human Activities: Overuse
   - Urbanization, land developments, etc.

2. Decrease of Human Activities: Underuse
   - *Satoyama* (woodland/grassland rural areas) or paddy fields

3. New Crisis
   - Alien species, chemical material use, etc.

4. Climate Change

Many common species in rural areas have become endangered

<table>
<thead>
<tr>
<th>Paddy fields</th>
<th>Semi-natural forest</th>
<th>Semi-natural grassland</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Fish" /></td>
<td><img src="image2.jpg" alt="Tree" /></td>
<td><img src="image3.jpg" alt="Butterfly" /></td>
</tr>
</tbody>
</table>
Landuse changes in Japan

Areas of farmlands and abandoned farmlands

- Farmland area in Japan has been decreasing year by year.
- Abandoned area has been increasing since the mid 1980s.
  - The reduction of food self-sufficiency rate
  - The governmental policy of reducing cultivation acreage from 1971
Land improvements in Japan

Land improvements of paddy fields

- Land readjustment for the use of heavy agricultural machinery
- Installing irrigation ditches, drainages and farm roads
- Installing under-drainages to make well-drained systems

Percent of improved paddy fields has increased since the 1960s.
The area of improved paddy fields reached 60% in the 2000s, and since then the percent of improvements has been leveled off.
Before the 1980s, the amount of chemical fertilizers and pesticides use had increased.

Since the late 1980s, the amount of their use has decreased gradually.
  - Efficiency improvement by product developments
  - Impact levels of these chemicals on wildlife would be comparable.
Relationships between Agriculture & Biodiversity

- + sustainable use
- + habitat supply
- - over chemical use
- - over development
- - diseases, pests
- + variety of crop
- + natural enemy
- + matter cycle
Negative Effects on Wading Birds


- In autumn, the populations of paddy field-dependent species increased by the mid 1980s, but decreased gradually to present.

- In autumn, the populations of species that are NOT dependent on paddy fields fluctuated over time, but have not declined.

- This pattern was not seen in spring.

These findings suggest the negative impact of land improvements on wading birds in paddy fields of Japan, because the improved rice fields have no/less water in autumn and winter.
Negative Effects on Aquatic Plants

Effects of a rice herbicide, bensulfuron-methyl

Test plants | Toxic conc. (μ g/L)
---|---
Azolla japonica (free-floating fern) | 2.0 (EC50)
Salvinia natans (free-floating fern) | 0.22 (EC50)
Penthorum chinense (emergent dicot) | 1.6 (Acceptable Conc.)

Exposed concentration (μ g/L)

- All species tested will be extinct
- Paddy field: >100 μg/L
- Drainage: 1-10 μg/L
- River: 0-1 μg/L

These results indicate the negative impact of herbicide on aquatic plants distributed in paddy fields of Japan.
Agricultural activities form landscape mosaic, which promotes biodiversity.

Positive Effects of Agriculture

Legend
- Paddy field
- Upland field
- Deciduous forest (secondary)
- Coniferous forest (plantation)
- Bamboo
- Bush
- Grassland
- Marshy grassland
- Greenhouse
- Other open space
- Pond
- Channel
- House
- Pavement & road
Positive Effects on Butterflies

Relationship between butterfly species richness and landscape structure

<table>
<thead>
<tr>
<th>Land Use on One-side of Census Root</th>
<th>Land Use on Another-side of Census Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P) Paddy rice field</td>
<td>18  25  23  24  12  25  7  43  29  36  37  2  13  21</td>
</tr>
<tr>
<td>(A) Abandoned paddy</td>
<td>23  18  17  16  9  16  20  25  23  8  21</td>
</tr>
<tr>
<td>(M) Rice + Abandoned paddy</td>
<td>34  24  11  11</td>
</tr>
<tr>
<td>(U) Upland field</td>
<td>8  5  15  24  13  10  20</td>
</tr>
<tr>
<td>(F) Forest</td>
<td>16</td>
</tr>
<tr>
<td>(G) Grassland in slope</td>
<td>15</td>
</tr>
</tbody>
</table>

* Stream, ** Others.

Landscape of paddy field with stream, grass, and forest

High species richness

Habitat supply

Positive Effects on Butterflies

Forest edge

Edge species

Zephyrus

Grassland species

Fritillary

Grassland by cutting

By cutting forest edge, high species richness in grassland species.
Amano et al. (2008) investigated the effects of landscape structure on the species richness and the abundance of birds in rice paddy areas of central Japan.

- Agricultural wetland species particularly utilized rice fields in summer, but open water in winter.

- It is important to maintain a combination of rice fields and open water to satisfy multiple habitat requirements by agricultural wetland species throughout the year.

- The importance of temporal landscape complementation
Effects of Environment-friendly Farming

Environment-friendly farming includes various practices...

Weed control with paper mulch
Biological weed control (ducks)
Weed control with rubber mulch
Biological pest control (pheromone)

Plant flowers in field margins

We focused on no pesticide application.

from MAFF Japan HP
Amano et al. (2011) used the abundance data of *Tetragnatha* spiders, a good indicator of farming practices, in 230 rice fields of Japan.

Bayesian hierarchical models to predict the abundance of spiders for various pesticide applications with explanatory variables of site-specific factors.

It is important that the effectiveness of environment-friendly farming on biodiversity varies across regions.
It is important that the effects of environment-friendly farming on spider abundance can be altered by precipitation.

- Amano et al. (2011) also assessed the impact of site-specific factors on the effectiveness of environment-friendly farming on *Tetragnatha* spiders:
  - Temperature
  - Precipitation
  - Elevation
  - Forest area

- Spider abundance was increased with reducing number of pesticide applications.

- This increase was particularly high in areas with high precipitation.
1) The relationships between agriculture and biodiversity in rice paddy landscapes of Japan suggest that farmland improvements and the use of pesticides have negative effects on biodiversity, but agricultural activities also form landscape mosaic which promotes biodiversity through landscape complementation.

2) It is important to sustain agricultural activities for maintaining the landscape mosaic with making a possible effort to minimize negative impacts of farming practices on biodiversity.

3) One option for that would be further extension of environment-friendly farming.

4) The effectiveness of environment-friendly farming practices for biodiversity conservation depended on landscape structure as well as on climatic factors, and environment-friendly farming would be increased more efficiently by taking those into account.

Thank You!