Management of Paddy Field Conditions for Migratory Birds Linking Together with Lake Environment Conservation

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ABSTRACT

Floodwater on paddy field has various functions for better rice cultivation condition. The continuous flooding on the field simultaneously provides habitat for wildlife that prefer water rich environment. Recently, however, area and period of flooding on paddy fields have been reduced, to avoid adverse effects on sound rice root-growth, and for introducing heavier farm-machineries. Then, balancing roles of flood condition for rice cultivation and eco-system conservation is necessary. As a case of this issue, diagnostic study has been done on water management practices of paddy fields for rice production and for migratory birds that depend for their feed on the fields. In the rice producing area in the north bank of Lake Biwa, in Shiga, Japan, migratory birds Bewick’s Swans fly to and stay over the paddy fields in winter. In the field, the behavior of swans and condition of the paddy field had been observed for three winter seasons since 2000.

The field observations prove that Bewick’s Swan flies from the lake to only some particular fields with specific features of open wide view, surface soil and water condition, environment of surrounding fields, and presence of other animals. Based on the field observatory facts, to conserve the some paddy fields as the habitats of swans, the following measures on land and water management are to be proposed: i) not to allow construction of higher building in large block of paddy fields, ii) to implement well designed crop conversion program not to reduce the area of paddy fields where the birds can touch down and stay over, iii) to request to farmers not to plow some of their farms, and iv) to request to farmers to keep some of their farms submerged in winter. The condition of paddy fields for the water birds should be managed with improvement and conservation of the lake itself, which the migratory birds fly to and stay as main habitats.

Keywords: water management practice, paddy fields, wildlife habitat, Lake Biwa, Japan

INTRODUCTION

Paddy fields are usually submerged for better rice production. The water ponding on paddy field has multi-function including continuous water supply to rice root zone, control of weed growth, management of nutrient dynamics, and mitigation for rapid temperature change of the field. The continuous flooding simultaneously provides habitat condition for wildlife, which prefer water rich environment, forming aquatic eco-systems.

Paddy fields in Japan are submerged for about 100 days, and recognized as temporary shallow ponds with stable and continuous submergence, in view of ecological system formation. Continuous ponding and fewer predators let wildlife use the paddy fields as their habitats for the whole or part of their life period. For higher order predatory birds, paddy fields are convenient feeding ground with much food such as flogs and insects in paddy fields (Watanabe T. and Tanji K.K., 1998. Mukai A. et al., 2001). On the other hand, in Japan, the area and period of flooding on paddy fields have been reduced continuously, for avoiding adverse effects on sound root-growth and for introducing heavier farm-machineries, based on wide spread use of chemical fertilizer and herbicide as well as irrigation and drainage system improvement and farmland consolidation.

Therefore, better water management practices in paddy fields are to be developed taking these different competing constraints into account. In this paper, as a case of this issue in Japan, the author diagnoses the problem on water management practices of paddy fields for rice production and for migratory birds. In the rice producing area in the north bank of Lake Biwa, Japan, migratory birds Bewick’s Swans fly to and stay over the paddy fields in winter time. Bewick’s Swans are hatched in the Arctic Zone and migrate to Lake Biwa and stay from late autumn to early spring. To identify the impacts of the birds on rice production and to develop better water management practices suitable for both rice and birds, behaviors of the swans and condition of the paddy fields were observed for three winter seasons since 2000. The field observations resulted in some suggestions for modifying land use and water management practices in the region.
Outline of the Case Study and Method Kohoku Region of Shiga, Japan

The Kohoku Region of the north bank of Lake Biwa (Figure 1) is located in Shiga Prefecture, Japan. Its paddy fields, spreading over fertile flood plain of the Ane and Takatoki Rivers running into the Lake Biwa, are mainly of the beneficial area of the Kohoku Irrigation Scheme, of which command area is about 4,700 ha. Irrigation and drainage project and farmland consolidation projects had been carried out.

In this region, in winter season, many migratory birds flies from the Arctic Zone, and stay in the Lake Biwa and paddy fields in the shore. The Kohoku Town in the middle of the region is enthusiastic to conserve migratory birds, implementing bird education and founding the visitors’ center for wild birds.

Rice is cultivated in this region once a year from late spring to early autumn in the improved farmland. Almost all paddy fields are consolidated and adjacent to irrigation, drainage canals and farm roads. Basically, there is no water deficit in the region, except in extremely dry spell. The standard cultivation and water management practices and their periods are as follows; 1) tillage in March, 2) puddling in late April to early May, 3) transplanting in early May, 4) mid-summer drainage in July, 5) last irrigation in late August to early September, 6) harvesting in October, and 7) post harvesting tillage in November in places. In the former half of growing season, before the mid-summer drainage, paddy fields are continuously submerged, and in the latter half after the mid-summer drainage, the fields are intermittently submerged (Watanabe T. 1999). Some farmers plow their paddy fields after harvesting in November to dry up soil profile, expecting increased available nitrogen when they irrigate in the next spring.

With governmental policy or guidance, about one-fourth of paddy fields are converted to other crops, mainly wheat. When farmers grow wheat in converted fields, they cultivate field just after harvesting rice and sow seeds of wheat in October. They harvest wheat mostly in June, and after that they usually grow. After harvesting the beans, fields are cultivated in October and left until the rice growing season in the next spring. They are doing rotational cropping, and the converted fields make round in the region.

Bewick’s Swans Fly into Paddy Fields

The author focused on Bewick’s Swan or Whistling Swan Cygnus columbianus for the case study, since it is relatively friendly to human and easy to be observed by nonprofessional bird watcher. Bewick’s swan is a migratory bird of Anatidae. Adult has total length of about 1.2 m and both wings length of about 1.9 m, when wings are spread, and its average weight is 6 to 8 kg. They inhabit the Arctic Circle of the Eurasian and North America Continents, and in winter season migrate to southern regions of the continents. They migrate to the Honshu Island to Kyushu Island of Japan, from October to April. The number of Bewick’s Swans migrate to Japan has been recently increasing, as about 7,300 of them stayed over winter season in 1985 and about 25,000 in 1995. One of the reasons for this increase is conservation of habitats (Higuchi H. et al., 1996).

In Lake Biwa, since only thirteen Bewick’ Swans were observed in 1974, its number has increased and reached to 300 to 400 in these years, as shown in Figure 2 in Lake Biwa. Bewick’s Swans migrate to Lake Biwa, usually in November. The maximum number of the swan is observed in January. Most of them are observed in the north bank, since there are many algae that swans feed on. During night they stay over the Lake Biwa, and during daytime they take algae or aquatic plants in the lake, or fly over to paddy fields near the lake shore to eat fallen grains or second shoots of rice.
Since Bewick’s Swan can peck water plant less than 80 cm below the surface of water, higher lake water surface makes the swans to difficult to take algae and they fly to paddy field for their feeding. Strong wind and higher wave on the lake, which often occur in mid-winter, also let the birds fly to paddy fields for taking their food. When, they eat up the algae or water plant in the lake, of course, they try to find food in the fields. Consequently, after mid-winter many Bewick’s Swans are often observed in paddy fields. Figure 3 shows the number of Bewick’s Swan observed in the Kohoku Region and the number observed in paddy fields in the season of 1997-1998. In January and February, almost all Bewick’s Swans were observed in paddy fields, while the swans were observed only in Lake Biwa in October and November. Before returning back to the north, in February, they sometimes come into wheat fields and take wheat leaves. Farmers growing wheat may recognize swans staying over their fields as undesirable guests.

METHOD OF FIELD OBSERVATION

To examine the condition of the fields where Bewick’s Swan stayed and fed on, the items listed in Table 1 are observed from November 2000 to January 2003. Total fifty two fields were observed in eleven field blocks. The points of each item are below:

a. situation of flying; number of birds flew to fields and their behaviors in the fields, including landing, shifting, and feeding on, and other environment of the fields.

b. condition of water; surface condition of the field where the birds landed at and stayed over, including area and depth of ponding, and soil water content.

c. amount of available food; number and weight of fallen grains and second shoots of rice per unit area.

d. land use; cropping and land management of the wider field blocks that include the blocks birds flew into and stayed over and the other blocks where birds were not observed.

e. adverse impacts on wheat production; wheat growth in the fields where birds stayed and ate wheat leaves.

Table 1. Observed and measured items and parameters

<table>
<thead>
<tr>
<th>Item</th>
<th>Contents or parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flying</td>
<td>Number of birds flew to the fields, Behaviors of the birds on feeding on and moving, surrounding environment, etc.</td>
</tr>
<tr>
<td>Ponding in fields</td>
<td>Area and depth of water pool in the fields, irrigation and drainage canals, situation of irrigation system management, soil water contents, etc.</td>
</tr>
<tr>
<td>Food availability</td>
<td>Number and weight of fallen grains and second shoots of rice per unit area.</td>
</tr>
<tr>
<td>Land use</td>
<td>Land surface condition, especially in the field blocks where Bewick’s Swans stayed</td>
</tr>
<tr>
<td>Damages on pecking</td>
<td>Weight of the wheat leaves.</td>
</tr>
</tbody>
</table>
OBSERVATION RESULTS AND DISCUSSIONS

**Observed behaviors of birds**

The field observation on the behaviors of Bewick’s Swans for three migration seasons from 2000-2001 provides the following facts.

a. The Bewick’s Swans fly away from the Lake Biwa to paddy fields in morning, at around 8 am, making a formation of two to twenty birds.

b. After coming down to paddy fields, they stay over the same field block with about ten plots in the morning. Then, in the afternoon, they separate and move to some different field blocks.

c. After coming down to paddy fields and moving around in the field block, finally they get together and peck feed at a few spots in the block.

d. The swans land at un-tilled field plots with fallen grains and second shoots of rice. They may land at wheat fields when there are no un-tilled fields.

e. The plots that the swans land at hold larger portion with ponding.

f. There are more fallen grains at the spots where the swans meet and take food together within the field block. However, the amount of fallen grains in a field block where the swans have not come has no significant difference with the amount in the blocks where the swans come and stay over.

g. The Bewick’s Swans fly away to the field block with wider view, or no higher buildings blocking the view.

h. The swans fly into the field block with several adjoining un-plowed plots.

i. The Bewick’s Swans look uneasy or scared at dog coming on farm roads, while they do not look nervous about human and car passing on farm roads.

**Figure 4** shows examples of the situation on landing, spreading and getting together of the swans, observed in the Shimoyagi District of the case study area in November 2000. The figure depicts that the observed one hundred and two swans landed at particular spots in two plots, and then they spread around six plots. Finally, they got together at three spots with much fallen grains. **Table 2** shows the similar observation results with numbers of fields or spots in the same year 2000-2001 in some districts. The differences of the available fallen grains in the different fields from the perspectives on the point above are plotted in **Figure 5**, showing relatively higher availability of the rice grain in the spots where the swans fed on.

![Figure 4. Situation on landing, spreading and getting together of the swans (in the Shimoyagi District of the case study area, November 23, 2000)](image)

Figure 4. Situation on landing, spreading and getting together of the swans (in the Shimoyagi District of the case study area, November 23, 2000)

<table>
<thead>
<tr>
<th>District</th>
<th>Yagihama</th>
<th>Tomita</th>
<th>Tanaka</th>
<th>Simoyagi</th>
<th>Minami Hayami</th>
<th>Daikoji</th>
<th>Enshoji</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plot the swans stayed over</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Plot the swans landed at</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Spot the birds finally got together</td>
<td>Not observed</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>
Figure 5. Number of average available fallen rice grains in the plots (2000-2001)

Figure 6. Distribution and depth (cm) of water pools in field plots (In the Yagihama District, 2000)

**Conditions of the field that the birds stay**

As pointed out in the previous section, Bewick’s Swans can land at un-plowed wet field with some submergence.

Figure 6 shows the water ponding area and the average depth of water pool of neighboring two plots as example; one is the plot where the swans landed at and the other is the plot where the birds moved to and stayed after landed. In the plot that the birds landed at, larger continuous water pool was found and its average depth in the central part is more than 3 cm. On the contrary, in the plot that the bird did not land at, there is no continuous water pool with a certain depth over 3 cm. In the other field blocks where the birds flew visited, larger continuous water ponding of 3 cm in depth was found. It is observed, however, that the Bewick’s Swans actually could land at some plowed plots where continuous water ponding was found. They also landed at plots covered by snow where also continuous water pool was found in snow cover.

Figure 7 illustrates the land use of the farm plots in two districts where the Bewick’s Swans were observed. It classifies the surface condition of the plots; un-plowed with ponding, un-plowed without ponding, plowed, and wheat crop growing. It shows that the birds’ visiting plots are located in the middle of larger farm district, where plots conserve wider view without higher buildings near by, as mentioned in the previous section.
Impacts of the Bewick’s Swan on wheat production

The Bewick’s Swans fly into and stay in the wheat fields, temporarily converted from paddy, in the latter stage of their migration in January and February. In the morning, they fly from Lake Biwa and land at paddy plots that satisfy the required conditions. After landing, they stay in the neighboring paddy fields, and then in the afternoon they fly short to wheat fields nearby and eat leaves of wheat. The time that they stay in wheat fields increases as the migratory stage goes on, and finally they stay there almost whole daytime.

Since enough fallen grains in paddy fields are available when the swans feed on in wheat fields, the reason of their staying in wheat fields is not lack of food in paddy fields. There must be some different reason that they prefer wheat leaf to rice grain in the latter migratory stage, especially before flying back away to the north. This reason is not certain and under discussion in field of bird ecology.

The Bewick’s Swan pecks wheat leaves of tillering stage, and the farmers growing wheat are worried about damage on the wheat yield. Wheat growth and yield was observed in the protected area in the wheat field where swans stayed and pecked the leaves in 2002. The protected zone was fenced-off to prevent the swans from pecking wheat leaves. There was no significant difference in wheat yield between the protected zone and the other free feeding areas, and hence any evidence for yield damage caused by the swan was not detected.

Interests of stakeholders on the Bewick’s Swan

The interviews with the stakeholders in the region on the Bewick’s Swan prove following their interests and concerns.

CONCLUSIONS AND SUGGESTIONS

Based on the field surveys, the conditions of paddy fields that the Bewick’s Swans can use as their habitat are clarified, leading to some requisites for conserving paddy fields as habitat of Bewick’s Swans. The required measures with some guideline are listed below.

1. i. To keep some paddy fields with ponding in field block that Bewick’s Swans can fly into. The ponding area of a plot is to be more than 40% of its total area.
2. ii. To keep four neighboring un-plowed fields.
3. iii. Not to construct higher building within 100 m from the field block that the swans can visit to keep wider view from paddy blocks.
4. iv. To keep people and dogs more than 100 m away from the birds.
5. v. To prepare some wheat growing plots that satisfy the requisites above No. i to No. iv.

To secure enough paddy fields that satisfy the requisite above, it is necessary to manage the distribution, area of crop conversion, to modify water management practices in the irrigation system and paddy fields. Farmers are to be asked not to plow their fields after rice harvesting to keep the surface condition for the Bewick’s Swans. These modifications in planning and operation may need much labor and cost in farmhouse and water management organizations.

According to the findings in this research, further works on the following subjects are needed.

a. Behavior of Bewick’s Swans, especially on their diet including necessary components, form, weight, etc.
b. Required conditions of Lake Biwa as feeding place and roost of Bewick’s Swans, including growth of aquatic plants, weather and fluctuation of water table of the lake, and other environments.

c. Detailed conditions of fields, which can be practiced by farmers and related organizations, especially feasible soil and water management practices, operation and maintenance of irrigation and drainage canals, design of rotational crop conversion, etc.

d. Relation with other birds and wildlife, including conflicts with required field conditions for other migratory birds that fly to paddy fields and for other lives living in paddy fields.

e. Regional environment conservation planning, taking advantage of more migratory birds in the fields and well designed paddy field management.

The paddy fields in the case study region were inundated widely when the lake water table was high in severe flood period, until a hundred years ago. The fields were a part of the Lake Biwa. The swans that fly to the paddy fields need nowadays both the lake and the farmland. Some paddy fields, which were inner lake of Lake Biwa, had been restored to lake for recovering its eco-system, stopping rice cultivation and submerge for all year around. If the swans do not to come to the Lake Biwa from the northern region with deterioration of lake environment in terms of water level, water quality, feed like aquatic plants and human influences, improvement of field condition for them would be insignificant. In this stage, the strategic management of the hydrological environment of the region consisting of the lake, inner-lake and paddy fields is required. It is to be not only for the wildlife like birds, but also for integrated region environment management.

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