J. Ecol. Field Biol. 29 (2): 165～169, 2006

〈Report〉

Evaluation of Winter Barley Fields as Feeding Habitat for Waterfowl in the Dongup Reservoir System, Korea

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ABSTRACT: As a Biodiversity Management Plan in S. Korea, barley fields are being prepared for the wintering migratory birds. However, the effectiveness of barley fields as a feeding habitat has not been evaluated. In 2003/04 wintering period, we installed exclosures in the barley fields to evaluate the waterfowl grazing effectiveness. Approximately 8,000 waterfowls used the Dongup Reservoir System and utilized the barley fields during the daytime. The white-fronted goose *Anser albifrons* occupied more than 90% of the all barley-feeding waterfowls. Waterfowls significantly impacted to the shoot density and biomass of barley. In the closed plot, barley shoot density gradually increased to 267±27/m^2 in January, 2004. Shoot density in open plots (site 1) declined sharply from 15 December (189±18/m^2) to 5 January 2004 (25±11/m^2). However, barley shoot density in open plots (site 2) was stable in January 2004 because of human disturbances. The changes in barley biomass and shoot density showed similar trend in both open and closed plot. From the exclosure experiment, it was clear that barley fields were important feeding habitat for wintering waterfowls in this area. Further, human disturbances such as noise from traffic and other human activities (farming and hiking) had significant impact on waterfowls' grazing activity. Collectively, winter barley fields were effective for waterfowl feeding, but the location of barley fields should be carefully selected for the maximum utilization of the barley feeding.

Key words: Barley fields, Dong-up Reservoir, Waterfowl, White-fronted goose

INTRODUCTION

Wetland habitats are unique biotic communities involving diverse plants and animals that are adapted to shallow and often dynamic water regimes. Also wetland birds are extremely diverse, reflecting early anatomical and physiological adaptations to this unique but rich habitat. For these reasons, many ecologists feel that birds are one of the more visible indicators of the total productivity of such biotic systems (Weller 1999). These important aquatic habitats for waterfowls are being destroyed and altered.

Worldwide, loss in wetlands has been estimated at 50% of those that have been in existence since 1900s (Davis and Hirji 2003). Significant efforts are now being focused on the voluntary restorations and creation of artificial habitats (Atkinson et al. 2001). Izunuma-Uchinuma Wetland is one of the most important wintering grounds for waterfowls such as whooper swan *Cygnus cygnus* and bean goose *Anser fabali*s. However, reclamation and overgrazing of waterfowl led to a lack of their main food source, water oat *Zizania latifolia*. Therefore, several restoration plans such as water oat bed restoration, construction of feeding ponds and riparian zone management were established (Ando 1998). In the Central Valley of California, USA, straw residue after harvest was traditionally disposed of by open-field burning. However, farmers are now required to adopt alternative methods. Winter flooding significantly increased waterfowl use of the field and waterfowl provide benefits to farmers in addition to enhancing straw decomposition (Bird et al. 2000).

In S. Korea, large areas of the tidal and estuarine wetlands were vanished due to reclamation projects. In the lower part of the Nakdong River, important waterfowl wetland habitats were vanished due to the construction of an embankment to protect farmland from flooding. Most of the riverine wetlands were converted to farmland from 1970s and only a few wetlands remained intact (Son and Jeon 2003). The decline in waterfowl population and the growing recognition of the biological and economic value of wetlands have led to wetland conservation efforts. Three artificial wetlands were constructed in the mid 1990s in the Nakdong River Estuary to compensate for the loss in wetland caused by reclamation (Joo et al. 2002). In 2002, the Ministry of Environment established the Biodiversity Management Plan for wintering waterfowls in the three important wetlands habitat. Several methods have been employed; not harvesting rice, winter barley fields, habitat protection for resting grounds and other waterfowl conservation activities (Ministry of Environment 2003). Currently, fourteen Biodiversity Management Plans have been implemented nationwide.

Dongup Reservoir System is located in the lower part of the

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Nakdong River. This wetland is one of the most important wintering waterbirds habitats in S. Korea (Cultural Heritage Administration 2001). In this area, the Ministry of Environment has established two conservation methods the regulation of water level in the Dongpan Reservoir and winter barely fields as a waterfowl food source. In 2002 winter barley fields were established as one part of the Biodiversity Management Plan nearby Dongup Reservoir. Although the Ministry of Environment had three years of practice, evaluation on the winter barley cultivation has not been made.

The aim of our study focused on the effectiveness of winter barley field as a waterfowl food sources. Therefore, we conducted field observations and experiments. First, we monitored the waterfowl in the Dongup Reservoir System to evaluate wintering waterfowl habitat use pattern. Second, we conducted exclosure experiment in the barley fields to determine the effectiveness of winter barely fields in this area.

STUDY AREA

The Dongup Reservoir System consists of three separated reservoirs (Junam Reservoir; 285 ha, Dongpan Reservoir; 242 ha, Sannam Reservoir; 75 ha). Originally, it was a riverine wetland in the lower part of the Nakdong River and situated in the inner part of the Daesan Plain (Yoon and Kim 1989). The Dongup Reservoir was constructed at a natural riverine marsh by installing dike in the 1920's for water supply to rice paddies. Most of the lands around the reservoirs are used for rice and orchard cultivation. The three reservoirs are characterized as large population of wintering waterfowl, shallow water depth (ca. 30～200 cm), various aquatic plants, diverse fishes and invertebrates reside (Yoon and Kim 1989, Hahm et al. 1999, Hahm and Kim 2001).

MATERIAL AND METHOD

To evaluate the habitat use pattern of wintering waterfowls, we conducted a biweekly census at the three reservoirs and rice fields using a point counts method (Bibby and Burgess 1992). In the winter barely field, we conducted wintering waterfowl monitoring and human disturbance to evaluate the daytime feeding pattern from 8:00 AM to 6:00 PM.

During the 2003/04 wintering season, barley seeds were sowed in the rice fields (a total of 593,750 m^2) after harvest from 1 to 10 November 2003. In the three sites exclosures were installed to evaluate the impact of waterfowl grazing activity on the winter barley crop (Fig. 1). We established exclosure in each site using iron nets (size; 5 × 5 m, mesh; 3 cm × 3 cm) to compare the growth of barley in open and closed experimental fields on 7 November 2003.

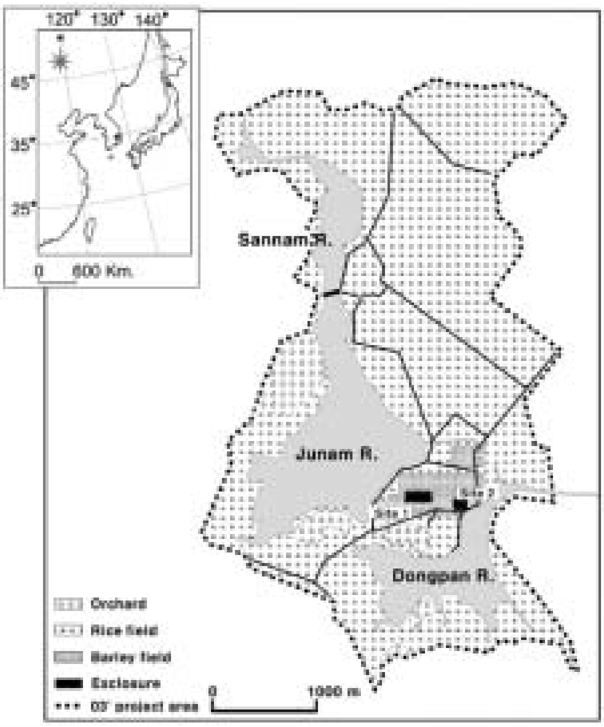

Fig. 1. The Dongup Reservoir System and the location of three study sites.

Site 1 is located in the center part of the winter barley field and contained three closed plots and three open plots. Site 2 is installed nearby a road (30～35 m) and farmstead (40 m) to evaluate the feeding habitats selection related to human disturbances. In the experimental site we sampled barley randomly 6 times from November 2003 to March 2004 to analyze the shoot density and biomass.

We used one-way ANOVA to compare the means of shoot density and its biomass of closed and open plots. After the ANOVA process, we adapted the Duncan test as post-hoc analysis to define the difference of shoot density and biomass among the plots. The statistical solution "SPSS for Windows ver. 11.5" was utilized to undergo statistical analysis.

RESULTS AND DISCUSSION

Population Changes and Daytime Habitat Use Pattern

In 2003/04 wintering season, waterbird population in Dongup Reservoir System rapidly increased from October and reached the peak number (about 8,000 individuals) in November (Fig. 2 A). A large number of wintering waterfowl utilized the Junam Reservoir until the middle of December. However, from late December 2003, most of the waterfowls moved to the Dongpan Reservoir. During late December, the Ministry of Environment requested the reservoir

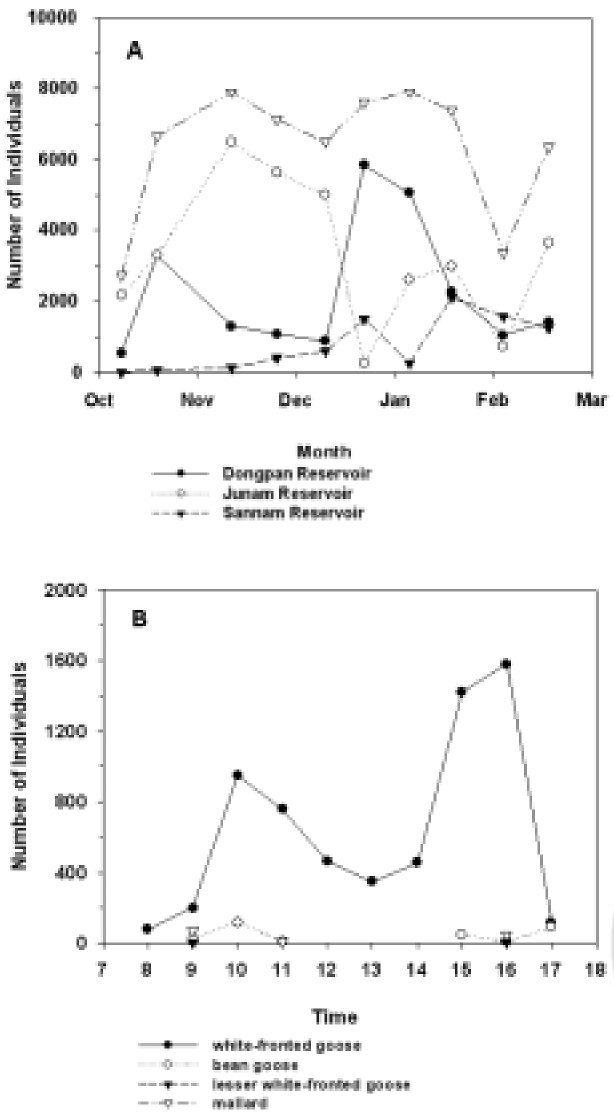

Fig. 2. Changes in waterfowl population in the Dongup Reservoir System (A) and the daytime changes of four waterfowl species that grazed in the barley fields (B).

management authority to decrease the water level in the Dongpan Reservoir in order to provide food for wintering waterfowl. Generally, water depth is the most important factor for waterfowl foraging (Elphick and Oring 1998, Faft et al. 2002) hence a large number of waterfowl utilized Dongpan Reservoir from late December to the middle of January 2004 (water depth; ca, 40 cm). Waterbird population in the Sannam Reservoir was consisted lower population than Junam and Dongpan Reservoirs because of the small size and permission of fishery activity in the reservoirs.

Census during the daytime habitat use pattern indicated that four species, such as the withe-fronted goose *Anser albifrons*, bean goose *Anser fabalis*, lesser white-fronted goose *Anser erythropus*, and mallard *Anas platyrhynchos* utilized the barley fields as a foraging site (Fig. 2B). White-fronted goose occupied more than 90% of the total barley-feeding waterfowls. Feeding activity at the barley fields started around 8:00 AM and the number of waterfowl increased until 10:00 AM. After 10:00 AM, they started moved to the Junam and Dongpan Reservoirs. During midday (10:00 AM～14:00 PM), the decline of waterfowl population could be observed which might be related to the disturbance caused by an increase in the number of eco-tourists. From 14:00 PM, the number of waterfowls increased again until 16:00 PM for feeding.

Change of Shoot Density and Biomass of Barley

In the winter barley fields, waterfowls grazed shoots from mid December 2003. Barley shoot density was sharply decreased in open plot in the site 1 whereas, shoot density of open plot in the site 2 decreased slightly. The changes of barley biomass showed a similar pattern to the changes in shoot density. According to post-hoc test, changes of shoot density were divided into two groups, while biomass divided into three groups (Table 1, Fig. 3).

During the study period, waterfowl grazing did not impact the barley population until mid December 2003. In open plot in the site 2, biomass decreased slightly from mid January 2004 and followed the trend of the closed plot in the site 1. In the closed plot, barley density gradually increased to 267±27/m^2 until 18 January 2004. From 15 December to 5 January 2004, the density of open plot in the site 1 decreased drastically from 189±18/m^2 to 25±11/m^2, whereas barley density in open plot in the site 2 was stable during this period. From the 5 of January 2004, barley shoot density of open plot in the site 1 showed significant difference compared to that of closed plot and open plot in the site 2 (F=84.757, P<0.05).

The change of biomass at both open and closed plots showed a similar trend of the density. From mid December 2003, the biomass of open plot in the site 1 decreased significantly (P<0.05). Biomass of open plot in the site 2 decreased from early January 2004. In the closed plot, barley biomass increased rapidly from November to January. However, from January to March the growth of barley reached a plateau because of severely cold weather (Fig. 3).

During the 2003/04 wintering season, a large number of waterfowls grazed in the winter barley field especially white-fronted goose. In Dongup Reservoir system, about 3,000 individuals of white-fronted goose *Anser albifrons* use the area as a wintering ground. Analysis of daytime waterfowl change, more than 50 % of white-fronted goose utilized the barley field (Fig. 2). Especially open plot in the site 1 was utilized as a feeding ground because the area was located in the middle of farmland. However, avian flush distance in response to various types of disturbance (Knight and Knight 1984)

Table 1. The result of statistical analysis (one-way ANOVA Duncan test as post-hoc) of barely density and biomass change in the closed and open plots

	Date	Closed	Open		Statistics	
			Site 1	Site 2	*F*	*P*
Shoot density (n/m^2)	`03. Nov. 7	15.3 ± 2.5	15.0 ± 2.6	15.6 ± 1.5	0.640	N.S.
	Dec. 15	20.8 ± 2.8	21.0 ± 2.0	20.7 ± 1.6	0.019	N.S.
	`04. Jan. 5	29.3 ± 4.1^a	2.8 ± 1.3^b	24.6 ± 1.5^a	84.757	0.000
	Jan. 18	29.6 ± 3.1^a	3.5 ± 1.3^b	23.3 ± 6.4^a	31.998	0.001
	Mar. 10	28.6 ± 1.5^a	10.6 ± 1.5^b	24.3 ± 3.2^a	52.956	0.000
	Mar. 24	28.6 ± 4.0^a	10.0 ± 5.0^b	23.3 ± 4.7^a	13.068	0.007
Total biomass ($g.dw/m^2$)	`03. Nov. 7	11.3 ± 3.3	11.1 ± 2.1	11.6 ± 0.9	0.039	N.S.
	Dec. 15	17.9 ± 3.1	17.5 ± 2.6	18.4 ± 3.2	0.050	N.S.
	`04. Jan. 5	26.6 ± 0.6^a	2.6 ± 1.9^b	24.6 ± 1.7^a	219.089	0.000
	Jan. 18	29.3 ± 5.7^a	2.7 ± 1.9^b	19.4 ± 3.8^c	31.740	0.001
	Mar. 10	29.1 ± 2.9^a	6.5 ± 3.2^b	20.5 ± 3.1^c	41.307	0.000
	Mar. 24	32.3 ± 2.0^a	8.1 ± 2.3^b	21.7 ± 3.5^c	61.147	0.000

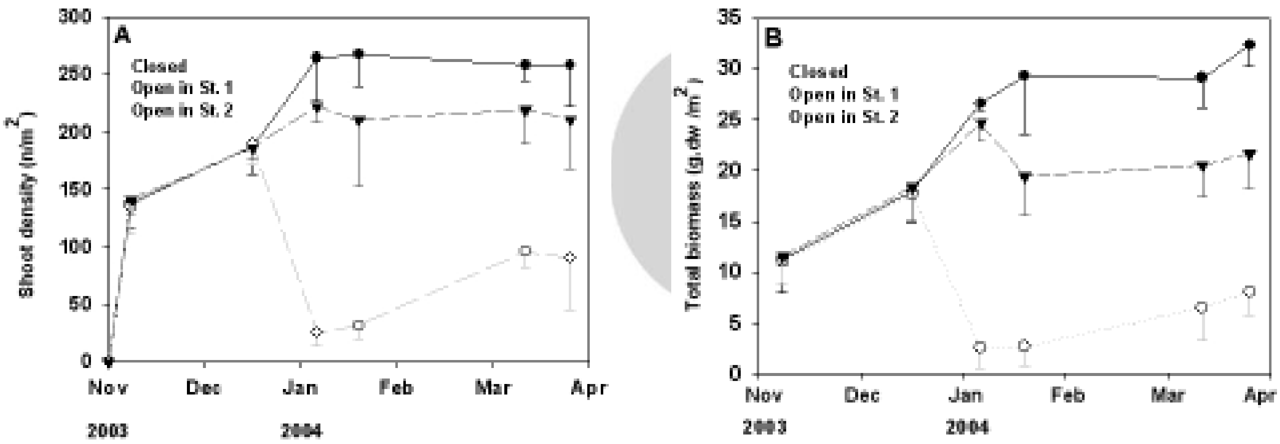

Fig. 3. Changes in barley density (A) and biomass (B) in the open and closed plots.

in open plot in the site 2 area waterfowl did not utilized sufficiently because the area was located nearby a road and farmstead. Even though, winter barley fields were effective for waterfowl feeding ground as one of the "Biodiversity Management Plan" the locations of barley fields was not carefully selected in the Dongup Reservoir System. Therefore, careful consideration of the buffer zone between foraging and human utilization zone should be considered in the winter barley field projects. In addition, financial benefits for the local community and other ecological factors such as the size of barley fields and flooding of rice paddies should be collectively considered.

ACKNOWLEDGEMENTS

We are grateful to the member of PNU Limnology Lab. for field assistance. This paper is contribution No. 44 of the ecological research of Nakdong River. This research was supported by Korea Ministry of Environment as “National Long-Term Ecological Research Project”

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(Received March 23, 2006; Accepted April 10, 2006)