A Study on the Proper Selection of Ecological Habitat for the Wild Radiation of Crested ibis (*Nipponia Nippon*)

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Abstract. This study aims to select the radiated area for the wild grazing of Crested ibis (*Nipponia Nippon*) in 2017 and develop a best-fit models for the wild grazing candidate area and dispersed area based on the existing restoration center in Gyeongnam area. According to the restoration policy of the endangered species Crested ibis, the regions that have a high suitability index are selected. In order to increase genetic diversity and prevent massive bird flu outbreaks, designating protection area for Crested ibis is necessary and it is recommended to release them in a geographically dispersed manner. As a result, the data obtained from the Crested ibis releasing could be shared with other restoration centers and also used as a basic data for the conservation of other endangered species in the entire Korea Peninsula.

1. Introduction
Crested ibis is a specially conserved species registered as a Vulnerable (VU) in the Red List of Endangered Species in 1988 by the International Union for Conservation of Nature (IUCN). In Korea, Crested ibis is extinct and it has been on artificial breeding since 2008. According to the Ministry of Environment’s propagation in July, 2008, the number of individuals of Crested ibis has been successfully increased from 2 to 313. Currently, Upo Restoration Center of Crested ibis cares for them. The geographical location of Korea allows to observe various species of birds for each season because of being in the middle of the East Asia-Australia route, that is one of the main routes of migratory birds. Especially, the Upo Swamp provides a resting place and a rich food resource for the birds and works as a representative wetland in Gyeongnam area.³

In celebration of 10th Meeting of the Conference of the Contracting Parties to the Convention on Wetlands, the re-introduction target for the wild grazing of Crested ibis was selected as Upo Swamp. It aims to preserve biodiversity through the restoration of Crested ibis, since the Upo Swamp and its surrounding paddies are properly managed under Ramsar Wetlands criteria. The preceded Crested ibis habitat suitability evaluation focusing on rivers and hills, that was conducted in China and Japan, excludes rice fields and their management. Hence, this study has a significance of providing a complimentary evaluation method to apply it in Korea.

Since Crested ibis is one of the most vulnerable species to avian influenza, its genetic diversity is difficult to be obtained. In this study, the habitat fit factors for Crested ibis were selected through expert questionnaire and the habitat evaluation index was selected considering the habitat environment of Crested ibis. This study aims to select the radiated area for the wild grazing of Crested ibis (*Nipponia Nippon*) in 2017, and develop a best-fit model for the wild grazing candidate area and dispersed area based on the existing restoration center in Gyeongnam area. If the population of Crested
ibis (Nipponia Nippon) is increased in the future, the risk of collective accidents should be reduced and genetic diversity should be ensured by dispersing wild grazing in suitable habitats.

2. Materials and Methods

2.1. Subject of Study

Crested ibis was a common species prevalent in Northeast Asia until the end of the 19th century. It was distributed in eastern Russia, Japan, and China, and it was bred throughout the whole of Korea. It was wintering throughout the Korean Peninsula and Taiwan, but it started to decrease rapidly from late 19th century to early 20th century.[2] One of the most recently endangered bird species in the world is the crested ibis (Nipponia Nippon; IUCN Red Data Book, BirdLife International 2001). It was once widespread across Northeast Asia, with a range encompassing China, Russia, Korea, and Japan until the 1860s. Suffering from over-hunting and habitat loss, the crested ibis populations had finally collapsed in the late 19th and early 20th centuries, to the extent that it was thought to be completely extinct from the wild.[3] Taxonomically, Crested ibis belongs to the Animal, Vertebrate, Avis, Ciconiiformes and Threskiornithidae. Twenty-eight species have been recorded all over the world, but the Crested ibis (Reunion Flightless Ibis, Threskiornis solitarius) is estimated to have been extinct since 1705. There are 27 species of crested ibis.[4] It was distributed all over the Northeast Asia region. In Russia, it was inhabited in the Amur River basin and Khabarovsk. As the amphibians, insects, etc. are exploding in summer during the summer, various birds have been used as breeding grounds as well as Crested ibis. Crested ibis seemed to have been found mainly for breeding in summer, but the winter temperatures in Russia are so low that it is hard to find food, so when winter arrives, it travels to the Korean peninsula or southeastern part of China or Japan. Except for a few species, Crested ibis has a very limited habitat, of which 7 species are in a state of extinction due to their reduced population. In addition to being designated as an endangered species, the loss of wetland behind and the lack of food resources in tofu are causing considerable threats to survival.

Although it is designated as National Natural Monument No. 198 in Korea, it is regarded as extinct because there is no record of observation since winter 1978.[5] The International Union for Conservation of Nature (IUCN) lists Vulnerable (VU) species on the Red List of Endangered Species.

In China, the Crested ibis restoration project was initiated at the national level. As the artificial breeding project succeeded, reintroduction of Crested ibis from China was promoted in Korea and Japan where wild Crested ibis was extinct.[6] The reintroduction of Crested ibis in China is known to return to the nature of artificially propagated Crested ibis, and the number of wild populations is now more than that of artificial rearing. In Japan and Korea, it is necessary to introduce species that have already been exterminated in the wild from China and to expand artificial rearing in Korea, or in the case of Japan as an initial stage of wild spinning.

Currently, Crested ibis is artificially multiplying for restoration in Upo Swamp in 2008 and plans to naturally emit Crested ibis in 2017. Therefore, we will select the joint area considering the species for Crested ibis radiation.

When Crested ibis is inhabited in one area, the habitat evaluation index is set according to the high possibility of bird flu and the like.

2.2. Study Methods

The research progresses in the order of the following figure (Figure 1). The purpose of this study was to investigate the current status of the Crested ibis’s habitat and select the factors through expert opinion for more objective and realistic emission. A study on the domestic preliminary research on ibis has been carried out in the selection of Crested ibis habitability factors in the DMZ as a military area.[7]
The restoration of Crested ibis was first performed in Japan and China, which are neighboring countries of Crested ibis distribution.

3. Results and Discussion

3.1. Study Methods

For the selection of the suitability factors for the habitat, the environmental and geographical characteristics of the Crested ibis were selected from the preliminary study and the opinions of six domestic experts of Crested ibis.

The fitness factors of the selected Crested ibis were as follows (Table 1).

Crested ibis was classified into five major factors to consider when selecting habitat. First, since the prey and habitat of Crested ibis are important factors, the feeding factors of Crested ibis and its approach should be easy.

The main food source of Crested ibis is loach, frog, insect, etc. Most of them live in rice fields.[8]

Second, the factors of breeding were selected as the evaluation items such as the distance of feeding grounds, breeding grounds, number of enemies, biodiversity index, and the labor and density of rice fields.

Table 1. Factors for habitat evaluation for Crested Ibies.

| Categories     | Evaluation factors | Value | Categories     | Evaluation factors | Value |
|----------------|--------------------|-------|----------------|--------------------|-------|
| Food Factor    | 1. A rice paddy    | Y/N   | Wintering Factor | 1. Depth of freshwater | 20cm |
|                | 2. Small irrigation ponds | Y/N   |                | 2. Partial freshwater in paddies | Y/N   |
|                | 3. Fallow ground biotope | Y/N   |                | 3. Safe feeding place | Y/N |
|                | 4. Eco-corridor     | Y/N   |                | 4. Safe sleeping place | Y/N |

Figure 1. Study flow
Based on the evaluation items of bird habitat suitability in the previous study, the priority item for the selection of the crested ibis wildfire area was selected and it can be used as an evaluation criterion for selecting the crested ibis area.

In particular, the results of the existing research mainly focus on the forests, and the focus is on the distance from the surrounding habitat types and the area of the connected space.

In this study, the breeding and wintering seasons, social factors, and surrounding environmental condition such as eco-friendly farming and pollution source. Biotop composition and double cropping are suggested as additional evaluation items.

Considering the food resources of Crested ibis, the establishment of a habitat for wild radishes is closely related to the behavior of local residents. Particularly, discussion management is more important because it plays a role of food habitat of Crested ibis. In this respect, consultation between local residents and the management is essential. Habitat management of the wildfire sites should actively encourage the participation of the residents adjacent to the target area and ensure that the habitat is sustainably managed through them and linked to various projects, including monitoring in the future.

### 3.2. Candidate Area According to Habitat Evaluation

According to the evaluation area, the top 5 sites in the area suitable for the Crested ibis habitat were selected from the 18 cities in Gyeongnam area where the Crested ibis restoration center is located (Table 2).

The site of Crested ibis radiation area in Gyeongsangnam-do was selected as the surrounding environment, food resources for wild spinning, and habitat conditions.

| No | Site                                               | Score | Fitness possibility |
|----|----------------------------------------------------|-------|---------------------|
| 1  | Bugok eco industrial park                         | 92.6  | suitability         |
| 2  | Bongha Village, Hallim-myeon                      | 89.4  | suitability         |
| 3  | The IPO Wetland                                    | 87    | suitability         |
| 4  | Bu-ri, Chahwang-myeon, Sanhcheong-gun              | 85.4  | suitability         |
| 5  | Gyeongsangnam-do Forest Enviroment Research Institute | 83.4  | suitability         |
Crested ibis wild grazing was firstly applied in the area where sufficient feeder and habitat were established. Among the 19 areas of Gyeongsangnam-do, there are eco-friendly agricultural complex area and Gyeongsangnam-do forest environment research area. However, this area is a place where residents and local governments need to consult. Crested ibis has been ranked as the No. 1 place in the Bonggok Ecological Agricultural Zone in Changnyeong-gun, which is rich in food prefectures. However, this area needs to be discussed by residents and local governments. Respectively. In particular, Upo Wetland is the second most important wetland in the world and registered as a Ramsar Convention in 1998, and is regarded as an important habitat for waterbirds. Upo Wetland is a region with a size of about 700,000 pyong. Rice fields and fields formed around Upo Wetland can be suitable places for wild animals that rely on farming culture and aquatic ecosystem like Crested ibis. The reason why the restoration center is located in Upo Wetland is the reason for this evaluation.

4. Conclusion
This study evaluates the five habitat suitable elements to choose five regions in Gyung-nam area for releasing Crested ibis. The five factors for evaluation are ‘Food Factor’, ‘Reproductive Factor’, ‘Wintering Factor’, ‘Social Factor’, and ‘Environment’. The regions that have enough feeding grounds and breeding habitats are prioritized. As a result, Buggok Ecological Farming Complex in Changnyeong-gun is selected as the first place with abundant feeding grounds and Bongha Village in Gimhae and Upo Swamp ecological agriculture complex are following. However, since Buggok Ecological Farming Complex requires resident agreement with local government, Bongha Village and Upo Swamp ecological agriculture complex are considered more suitable. According to the restoration policy of the endangered species Crested ibis, the regions that have a high suitability index are selected. In order to increase genetic diversity and prevent massive bird flu outbreaks, designating protection area for Crested ibis is necessary, and it is recommended to release them in a geographically dispersed manner.

In condition of a successful Crested ibis releasing, it could be associated with ecotourism. For example, Japan runs the Crested ibis Forest Park and the Crested ibis Village around the protection area and China is currently developing the restoration program in collaboration between the government and local residents. Crested ibis restoration and wild spinning is not a simple species restoration project. It must be accompanied by a national effort for biodiversity, awareness of environmental conservation in the local community, and education of community members who are stakeholders, as a place branding business. Additionally, the data obtained from the Crested ibis releasing could be shared with other restoration centers and also used as a basic data for the conservation of other endangered species in the entire Korea peninsula.

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