Patterning habitat preference of avifaunal assemblage on the Nakdong River estuary (South Korea) using self-organizing map

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ABSTRACT

A comprehensive monitoring of the avifaunal assemblage to observe patterning changes was attempted for an estuarine system in South Korea. The current work identifies the importance of conserving habitat for migratory birds especially in the studied Nakdong River estuary. This estuarine system has been recognized as one of the most important stopover sites on the East Asia–Australasian Flyway, and supports a high level of biodiversity. The installation of an estuarine barrage in 1987 resulted in the habitat being partitioned into freshwater and brackish areas; however, there has been no systematic monitoring throughout the estuary. In the original survey program, the entire system (ca. 100 km^2) was divided into eight sites and monthly or biweekly monitoring was implemented for the 3 years from April 2003 to March 2006. 227 species of birds were observed, with the dominant species being mallard (*Anas platyrhynchos* Linnaeus) (relative abundance, RA, 17.2%). Assemblage parameters showed avifauna biodiversity possessed a strong seasonality with some species groups dominating the estuary. A non-linear patterning self-organizing map (SOM) algorithm was applied to the avifaunal data set to identify patterns in avifaunal distribution. The trained SOM model (quantization error, 3.375; topographic error, 0.000) clearly classified the bird data set into two clusters. These clusters could be characterized by two factors: i.e., seasonal distribution of avifaunal assemblage and/ or habitat properties. High dissimilarity between clusters was due to seasonality, while the brackish area (i.e., the cluster 1) was mostly occupied by cold season data while the reverse was true for cluster 2. By comparing bird data from the sub-zones, it was found that the center of the brackish area had a mixed pattern of bird distribution, which implied this area could be more important in terms of habitat preference with respect to migratory bird distribution. From the results, it is strongly suggested that a strict management strategy for the estuarine area to conserve the avifauna throughout the migratory flyway be prepared. The strategy could be seasonally and species specific.

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1. Introduction

The worldwide loss of wetlands has significantly accelerated the dissemination of awareness about wetland-dependent organisms like waterfowl. The estuarine area is recognized usually as an important habitat for waterfowls which inhabit or temporally use these areas (Mitsch and Grosselink, 2000; McKinney et al., 2006; Madhu et al., 2007). It is known that highly a variety of microhabitats for feeding, nesting and resting, as well as food richness allow waterbird assemblages to utilize these systems (Mitsch and Gosselink, 1993). For managed wetlands, this equals the desired goals, such as attracting a diverse and abundant waterbird assemblage by providing a diversity of foraging habitats (Fredrickson and Reid, 1986; Velasquez, 1992; Laubhan and Fredrickson, 1993; Sanders, 2000).

Many studies have addressed the mechanisms and adaptive consequences of habitat choice by waterfowl (Cody, 1974). Habitat loss is the greatest threat to biodiversity and habitat protection is the most important means of conserving biodiversity (Primack, 1995). Their habitats are increasingly affected by the expansion of human population (Terborgh, 1989), which is particularly true for coastal wetlands.

Habitat patterning is, in this sense, an important process for the establishment of a habitat management strategy. Through relevant pattern analysis of waterbird distribution in their habitats, it is possible to detect sensitive areas for migratory bird assemblages. Among diverse methodologies for distribution pattern analysis, recent applications of self-organizing map (SOM) are notable (e.g., Chon et al., 2000; Joo and Jeong, 2005).

The Nakdong River estuary is an important wintering site for migratory waterbirds in South Korea. This area, located in the middle part

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of the East Asia–Australasian Flyway, provides a wide variety of food sources (e.g., macrophytes, benthic macroinvertebrates, and fish) on its mudflats. It possesses high productivity and a complex trophic structure caused by tidal activity. Losses of wetlands and riparian zones along the lower Nakdong River have accelerated due to industrialization and urbanization since the 1980s and the residential area expansion in the 1990s. Furthermore, changes in the structure and function of the estuarine ecosystem accelerated after construction of an estuary dam in 1987 (Ministry of Environment, 2005). Despite the significance of the Nakdong River estuary as an important waterbirds' habitat, there have been limited systematic studies of this site with respect to avifauna biodiversity or habitat modification. The installation of the estuarine barrage in 1987, which partitioned the estuarine habitat, was not strongly scrutinized.

The present study focused on discovering patterns in the distribution of bird assemblage in the Nakdong River estuary. Various indices of biodiversity were evaluated using the bird assemblage database. An SOM model was developed based on a three-year data set for bird assemblage and sub-zones classification results of the estuary analyzed. Seasonality as well as spatial distribution of bird species was considered in the interpretation of modelling results. Habitat characteristics of the divided sub-zones were considered in relation to the distribution of bird assemblage. The results of this study may provide significant information for habitat conservation in the Nakdong River estuary.

2. Materials and methods

2.1. Description of the study site and avifauna survey

The Nakdong River estuary is located in the southwest part of Busan Metropolitan City (35° 05′ N, 128° 55′ E) in South Korea. This area is located in the middle of the East Asia–Australian Flyway (Lee, 2007) (Fig. 1). The estuary covers ca. 100 km², and possesses diverse habitats produced from the interaction of the tides, the delta, tidal marshes, and associated wetlands.

Bird surveys were conducted twice a month from April 2003 to March 2006 in the Nakdong River estuary. Each bird census was conducted by point counts and the line transected method (Bibby et al., 2000) at the eight sites (Fig. 1). In order to investigate how avifauna
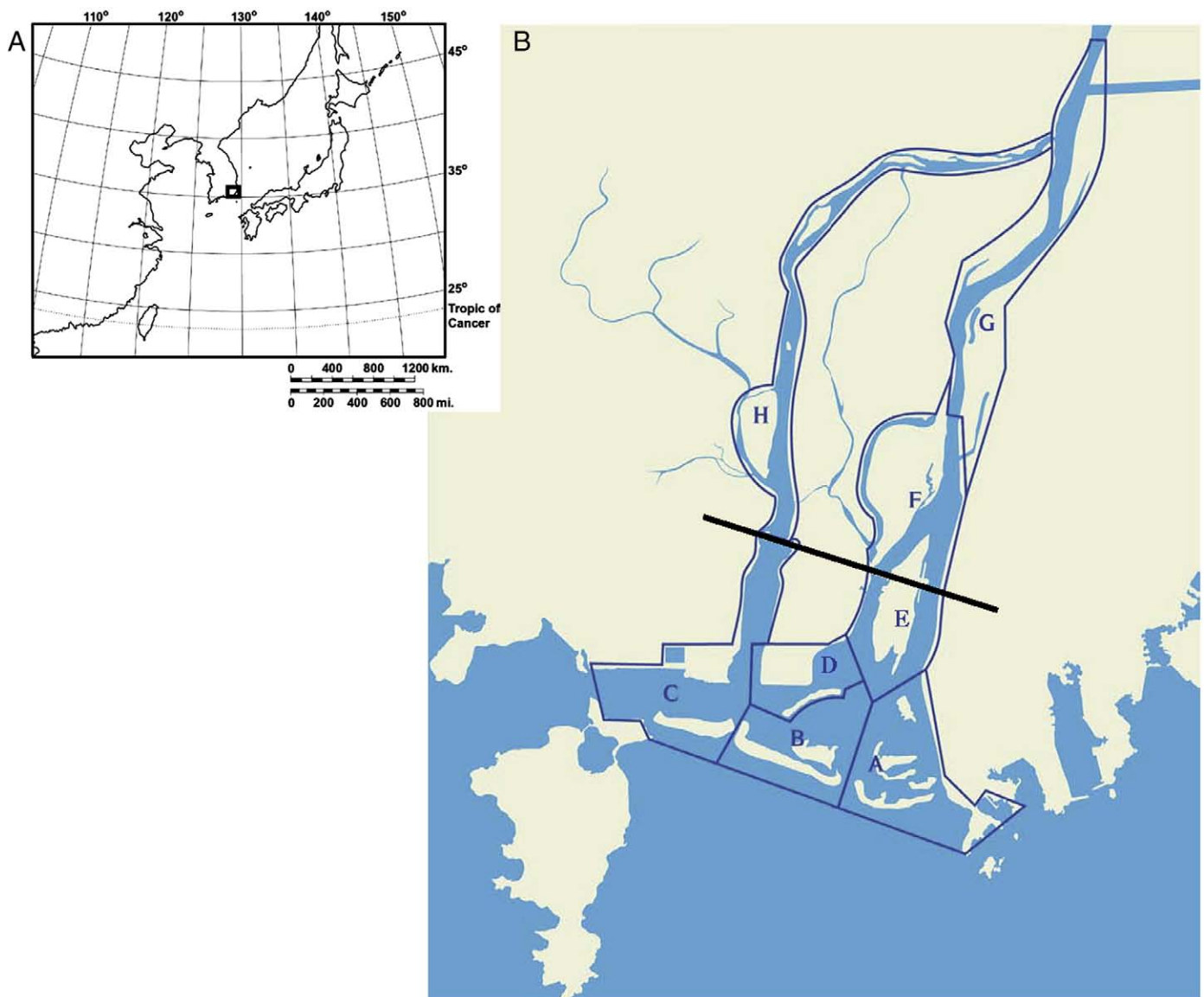

Fig. 1. Map of the study sites. A, Eastern Asia showing the location of the study site; B, the study area (the Nakdong River estuary) consisted of 8 sites for bird monitoring. The black line crossing the sites E and H indicates the estuarine barrage.