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Foraging Habitat Preferences of Herons and Egrets

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ABSTRACT: We investigated the foraging habitat preferences of herons and egrets in an agricultural area in Asan city, Chungcheongnam-do, Korea. In the study area, rice fields were the most abundant habitat type (86.8%) and total suitable feeding habitat was greater in the northern area (59.0%) than the southern area (22.5%) of the colony. Most feeding herons and egrets were located in the northern area of the colony. The number of feeding individuals in a given area was related to the available feeding area (Pearson correlation, r=0.773, p<0.001 for field habitats; r=0.901, p<0.001 for freshwater habitats). Feeding habitat preferences differed among species. Grey herons (*Ardea cinerea*), great egrets (*Egretta alba*), and black-crowned night herons (*Nycticorax nycticorax*) used reservoirs and ditches. However, intermediate egrets (*E. intermedia*) and cattle egrets (*Bubulcus ibis*) were dependent on rice fields. The little egret (*E. garzetta*) was a habitat generalist using all types of habitats. The two largest species, grey herons and great egrets, fed at deeper site than little egrets and foraged in deeper sites in reservoirs than in ditches (χ^2-test, χ^2_3=26.6 and p<0.001 for grey herons, χ^2_3 =17.5 and p<0.001 for great egrets). All species displayed seasonal changes in feeding habitat use and these changes were related with changes in availability of feeding habitats.

Key words: Ardeidae, Egrets, Feeding habitat, Foraging, Habitat preferences, Herons

INTRODUCTION

Wetlands support several species of waterbirds and each species use available habitats and resources in different ways. The availability of feeding habitats is related to breeding success and population sizes (Hafner 1997). The choice of feeding habitat is particularly important in nesting seasons since energetic demands on adults are greater in the breeding season than the non-breeding season (Erwin 1985). In mixed-species colonies, inter-specific competition for food resources can occur, and therefore species may partition resources by using different prey types, feeding habitats, and foraging times (Smith 1997).

Bird species in the family Ardeidae (herons or egrets) are found in aquatic habitats worldwide (Kushlan and Hancock 2005). They are generally tall and slim, with long bills, a long neck, long legs, and long toes. They use a variety of habitats, including many human-altered landscapes. Most heron species are highly dependent on wetlands, but some also feed on dry land. They mainly feed on aquatic prey such as fishes, amphibians and aquatic insects, while some species also feed on terrestrial prey such as small mammals and insects (Kushlan and Hancock 2005). The choice of foraging habitats in heron species is influenced by several factors such as prey density (Hafner and Britton 1983, Draulans 1987, Kersten et al. 1991), habitat type (Erwin et al. 1985, Tojo 1996, Dimalexis et al. 1997, Wong et al. 2001), and water level fluctuations (Kushlan 1986, Smith 1995), etc. Moreover, the availability of food often varies both temporally and spatially. Therefore, the choice of foraging locations by feeding herons is also likely to vary across time and space (Hafner and Britton 1983, Maccarone and Parsons 1994).

Understanding ardeid feeding habitats and habits as well as nesting habitats is important for conservation. In Korea, there has been some research about ardeid breeding ecology (Yu and Hahm 1997, Kim et al. 1998, Kim and Koo 2007) and characteristics of nesting habitats (Lee et al. 2007), but species-specific feeding habitats and prey types are not fully understood. This study investigates the feeding habitat preferences of grey herons (*Ardea cinerea*), great egrets (*Egretta alba*), intermediate egrets (*E. intermedia*), little egrets (*E. garzetta*), cattle egrets (*Bubulcus ibis*), and black- crowned night herons (*Nycticorax nycticorax*), the most common Ardeidae species in Korea.

STUDY AREA AND METHODS

The study area included an area of about 5 km radius (a total of 8,800 ha) around a breeding colony (36° 52' 25" N, 127° 02' 02" E) in Asan city, Chungcheongnam-do in Korea (Fig. 1). Although herons and egrets may feed over a wider area, most individuals prefer feeding habitat within 5 km from their breeding colony (Hafner and Britton 1983, Hafner and Fasola 1992, Wong et al. 1999). Therefore, we assumed that all herons and egrets observed

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in the study area were from this colony. The breeding colony is located near a reservoir that many herons and egrets use as a feeding site and included about 600 nests of grey herons (16.1%), great egrets (4.8%), intermediate egrets (11.3%), little egrets (19.4%), cattle egrets (21.0%), and black-crowned night herons (27.4%).

The study area contains several types of feeding habitats, such as reservoirs, ditches, grasslands, and rice fields. Water conditions in rice fields changed seasonally. In spring and summer (from late April to September), all fields were filled with water. After the crop harvest in early autumn (normally in October), water levels were reduced and most rice fields either held only some patches of water or were dried out. Most reservoirs were constructed for agricultural purposes, and their water levels also fluctuate seasonally: normally water levels are high in winter and low from late May to October, except in late June and July, the rainy season in Korea.

Monthly counts of feeding individuals were conducted from April to October 2006, except that two counts were conducted in May. Feeding birds were distinguished from roosting individuals either by their activities or postures. Roosting individuals were not included in the data analysis. We observed each feeding individual for 2~3 minutes and recorded the foraging habitat type and water depth. We distinguished 5 foraging habitat types: 1) reservoirs, including small ponds; 2) ditches, including small streams and irrigation channels; 3) rice fields; 4) rice banks (levees), defined as levees or paths covered by grasses around rice fields; and 5) grass lands. Water depth was estimated in relation to the leg length of the birds. Water depth was divided into 4 categories: (1) 0-Ts1/2: water up to the half of length of the tarsus; (2) -Ts1: water up to the joint of tarsus and tibia; (3) -Tb1/2: water up to the half of the length of the tibia; (4) -Tb1: water up to the belly of birds. Also, in rice fields, we distinguished the location of feeding birds into two areas, inner parts and edges (<1 m of the bank), including rice banks.

The area of foraging habitat were measured using a point sampling technique (Farinha and Leitão 1996) from 1:25,000 maps with a grid containing 400 points per km^2 (1 point = 0.25 ha) and field surveys. Non-feeding habitats, including villages, industrial areas, forests, mountains, and roads, were not included in the feeding area. The study area was divided into five sections: the center, the north-east section, the north-west section, the south-east section, and the south-west section (Fig. 1). Because many herons (especially grey

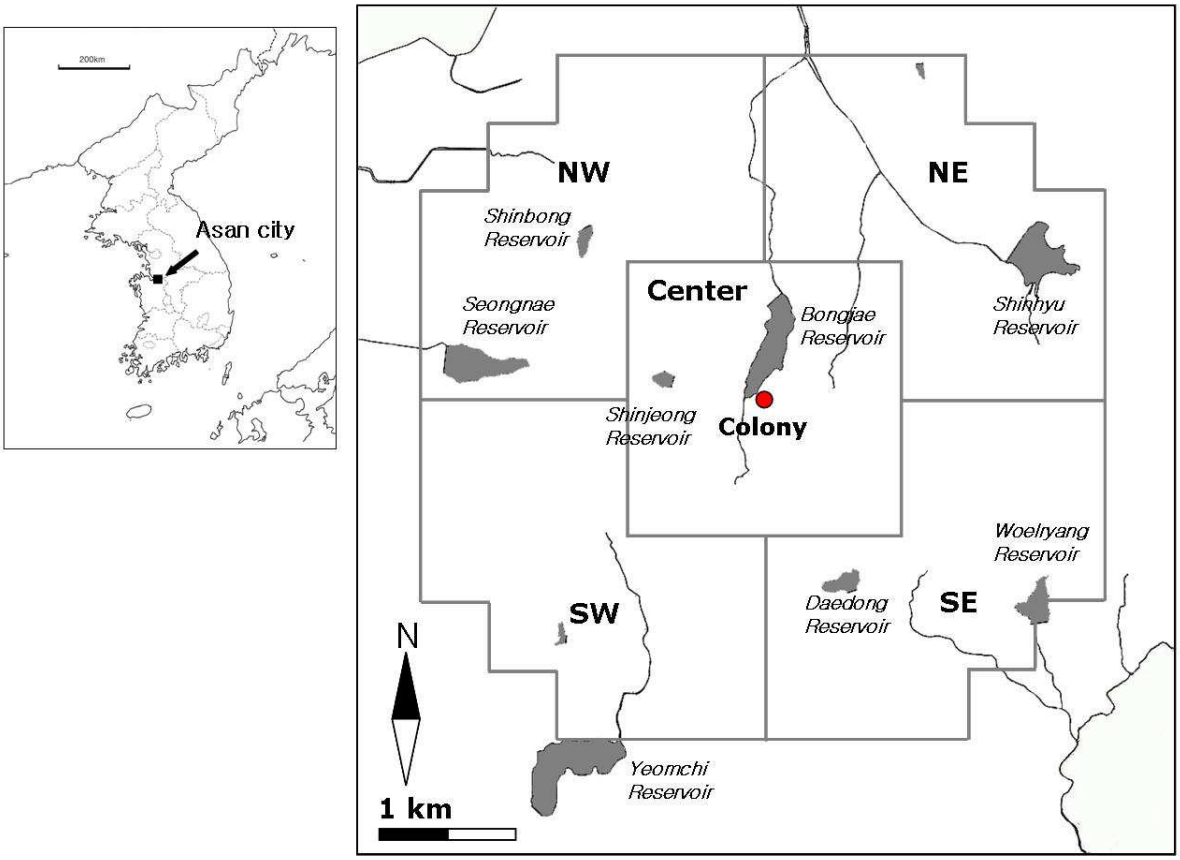

Fig. 1. Map of the study area showing main reservoirs and ditches around the breeding colony (solid circle at center). The study area is divided into five divisions or sections; center, north-east (NE), north-west (NW), south-west (SW), and south-east (SE).

herons) fed in the reservoir within 2 km from the breeding colony, we designated the area within 2 km from the colony as the center section (a total of 1,600 ha) and the remaining area was divided into four sections of equal size (each 1,800 ha). We examined relationships between the distribution of feeding herons or egrets and the area of feeding habitat. To evaluate the differences in foraging habitat selection among species, an ordination method, correspondence analysis (CA) was employed. The CA ordination was performed using the MVSP program (version 3.1) and all data were summarized on a monthly basis for each species. To compare the differences in water depth between habitat types for each species, we employed the χ^2 test using SPSS software (version 11.2) and statistical methods described in Zar (1999).

RESULTS

Feeding Area and Number of Feeding Ardeidae

The total available feeding area was estimated at 2,105.2 ha (23.9% of the study area). The remaining area (6,694.8 ha, 76.1%) was considered to be unsuitable feeding habitat for Ardeidae and consisted of mountains, forests, villages, industrial factories and roads. Rice fields were the most abundant feeding habitat type (1,828.8 ha, 86.8% of total feeding area) within the study area, followed by reservoirs (173.4 ha, 8.2%), ditches (68.1 ha, 3.2%), and grasslands (34.9 ha, 1.7%) (Table 1). Feeding habitat was the most abundant in the north-east section (639.8 ha, 30.4% of the total feeding area), followed by the north-west section (601.6 ha, 28.6%), center (389.4 ha, 18.5%), the south-east section (287.6 ha, 13.6%), and the south-west section (186.8 ha, 8.9%). Most herons and egrets were located in the north-east section (Table 2 and Fig. 2). Fig. 2 shows that the number of birds related to the area of feeding habitat. The total number of feeding individuals was correlated with area of feeding habitat in both field (Pearson correlation, r= 0.773, p<0.001) and freshwater habitats (r=0.901, p<0.001).

Foraging Habitat Preferences

Correspondence analysis revealed differences in feeding habitat types among the six heron or egret species (Fig. 3). The first CA axis (CA1) expresses the gradient in foraging habitat from field habitats (rice fields and grasslands) to freshwater habitats (reservoirs and ditches). The second CA axis (CA2) expresses the gradient in the condition of field habitats from wet habitat types (rice fields) to dry habitat types (rice banks and grasslands). The grey heron and black-crowned night heron foraged mainly in reservoirs and the great egret selected both reservoirs and ditches, whereas the intermediate egret and cattle egret preferred rice field and grass habitats. The little egret was a generalist in its selection of feeding habitats; it fed in all habitat types except for grass habitats.

Seasonal changes in habitat selection were found for some species (Fig. 4). Most species foraged more frequently in rice fields early in the year (April~June) than late in the year (July~October). Early in the year, some grey herons and great egrets foraged on rice fields, but after July they did not use rice fields. Two rice-field-dependent species, intermediate egrets and cattle egrets, foraged more on rice banks or grass lands than rice fields themselves in the later

Table 1. Foraging habitat types found within a radius of 5 km of the breeding colony

Area[1]	Area (ha) of habitat				Total
	Ditch	Reservoir	Rice field[2]	Grass	
Center	8.5	54.8	323.3	2.8	389.4 (18.5%)
NE	39.0	41.5	546.5	12.8	639.8 (30.4%)
NW	4.3	46.3	543.0	8.0	601.6 (28.6%)
SW	8.5	3.8	168.0	6.5	186.8 (8.9%)
SE	7.8	27.0	248.0	4.8	287.6 (13.6%)
Total	68.1 (3.2%)	173.4 (8.2%)	1828.8 (86.9%)	34.9 (1.7%)	2105.2 (100.0%)

[1] Area: NE, north-east; NW, north-west; SW, south-west; SE, south-east. See Fig. 1.
[2] Including rice banks.

Table 2. Mean numbers and percentages of feeding herons and egrets in each area

Area[1]	Feeding herons or egrets[2]						Total
	GH	GE	IE	LE	CE	NH	
Center	27.3 (33.9%)	7.3 (16.8%)	2.0 (13.2%)	7.0 (16.1%)	5.6 (11.6%)	3.5 (16.6%)	52.6 (20.9%)
NE	25.0 (31.1%)	20.9 (48.4%)	7.9 (52.1%)	18.4 (42.2%)	24.9 (51.3%)	10.5 (49.7%)	107.5 (42.7%)
NW	12.6 (15.7%)	8.9 (20.6%)	2.5 (16.5%)	10.1 (23.3%)	12.3 (25.3%)	4.0 (18.9%)	50.4 (20.0%)
SW	0.4 (0.5%)	1.0 (2.3%)	1.1 (7.4%)	2.5 (5.8%)	2.5 (5.1%)	0.1 (0.6%)	7.6 (3.0%)
SE	15.1 (18.8%)	5.1 (11.9%)	1.6 (10.8%)	5.5 (12.6%)	3.3 (6.7%)	3.0 (14.2%)	33.6 (13.4%)

[1] Area: NE, north-east; NW, north-west; SW, south-west; SE, south-east. See Fig. 1.
[2] Species: GH, grey herons; GE, great egrets; IE, intermediate egrets; LE, little egrets; CE, cattle egrets; NH, black-crowned night herons. Data presented as the monthly mean value of all observations.

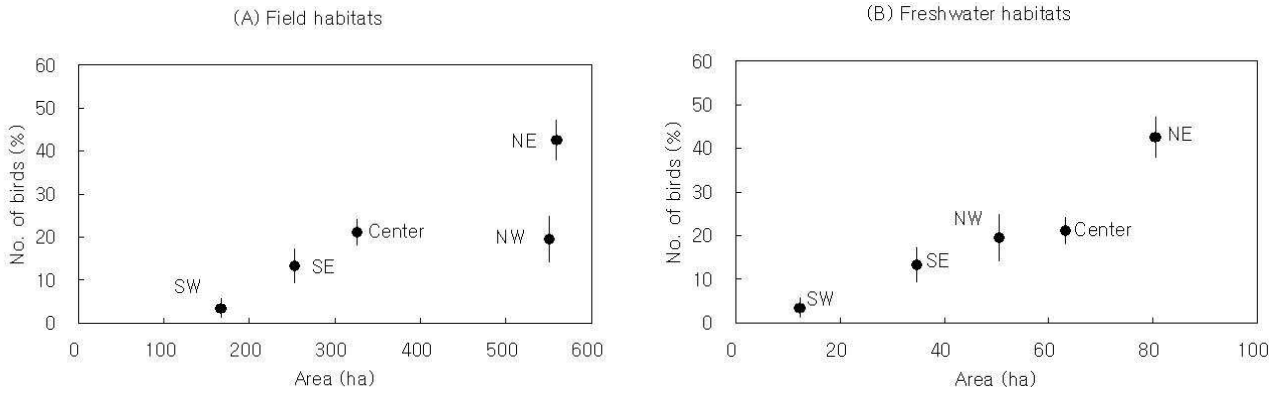

Fig. 2. Number of feeding herons and egrets in relation to the area of habitat: (A) field habitats and (B) freshwater habitats. Field habitats included rice fields and grasslands, and freshwater habitats included reservoirs and ditches. All data are presented as mean±SD. NE: north-east, NW: north-west, SW: south-west, SE: south-east.

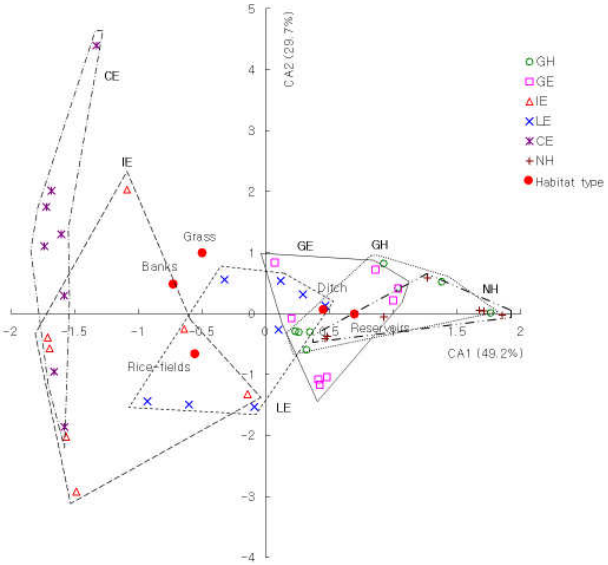

Fig. 3. Ordination plot of foraging habitat of six heron species on the first two axes from correspondence analysis (CA). GH: grey herons, GE: great egrets, IE: intermediate egrets, LE: little egrets, CE: cattle egrets, NH: black-crowned night herons.

part of the year. Most little egrets fed in rice fields in from April～June, but they used various habitat types later in the year. Black-crowned night herons fed mainly in reservoirs; a few individuals fed in rice fields from April～June.

Feeding Water Depth

Fig. 5 shows the depths of water in which three species foraged in reservoirs and ditches. The two large species, grey herons and great egrets, selected deeper sites than little egrets, but no difference is shown between the two larger species. Grey herons and great egrets foraged in deeper sites in reservoirs than in ditches (χ^2 test, grey herons: χ^2=26.6, *df*=3, p<0.001; great egrets: χ^2=17.5, *df*=3, p<0.001). Little egrets foraged at shallow sites in both habitats, but foraged at deeper sites in ditches than in reservoirs (χ^2=23.5, *df*=3, p<0.001).

Changes of Feeding Location in Rice Fields

In the early part of the field season, most feeding herons or egrets were located in the interior areas of rice fields, but they used the edges more in the later stages of the season (Fig. 6). For the two freshwater habitat foragers, grey herons and great egrets, only a small number of individuals foraged in the edges of rice fields in the later part of the season. The other three small species (intermediate, little, and cattle egrets) shifted their feeding locations from the interior areas of rice fields in the early part of the study season to the edges of rice fields in the late season.

DISCUSSION

The availability of feeding habitat is an important factor affecting bird populations. Many natural wetlands worldwide have been damaged by human activities during the last two centuries, and accordingly, many waterbirds have suffered population declines and range contractions (Dugan 1990). Agricultural wetlands, particularly rice fields, have provided year-round feeding and nesting habitats for several species waterbirds (Fasola and Ruiz 1996, Czech and Parsons 2002). In this study, rice fields were the most abundant habitat type and many herons and egrets foraged in rice fields. Moreover, more feeding herons were located in the north-east area of the nesting colony, which has the largest area of rice fields, than in any other part of the study area. Rice-field landscapes, including irrigation channels, ditches and reservoirs for providing water to fields, provide adequate populations of various aquatic prey (e.g., amphi-

bians, crustaceans, fishes and insects) to support a large number of waterbirds (Fasola et al. 1996, Lane and Fujioka 1998, Richardson et al. 2001).

In our study area, all heron and egret species foraged in multiple habitat types but frequencies of use of each habitat differed among species. Correspondence analysis showed that feeding habitat selection divided the species into group with similar niches (freshwater or field habitat foragers). Generally, the two largest species, grey herons and great egrets, preferred freshwater habitats over rice fields. On the other hand, intermediate egrets and cattle egrets entirely depended on rice fields and grasslands. These results suggest that different species display differences in foraging habitat preferences (Ramo and Busto 1993, Dimalexis et al. 1997, Smith 1997, Wong et al. 1999). Moreover, species employing the same habitat type tend to overlap little in their time of feeding, prey size or microhabitat characteristics such as water depth and vegetation type (Fasola 1986, Dimalexis et al. 1997). In reservoirs, most feeding grey herons and great egrets were located in open-water areas and in submerged or emergent vegetation, while little egrets were generally found on the shoreline, or in shallow water not exceeding half

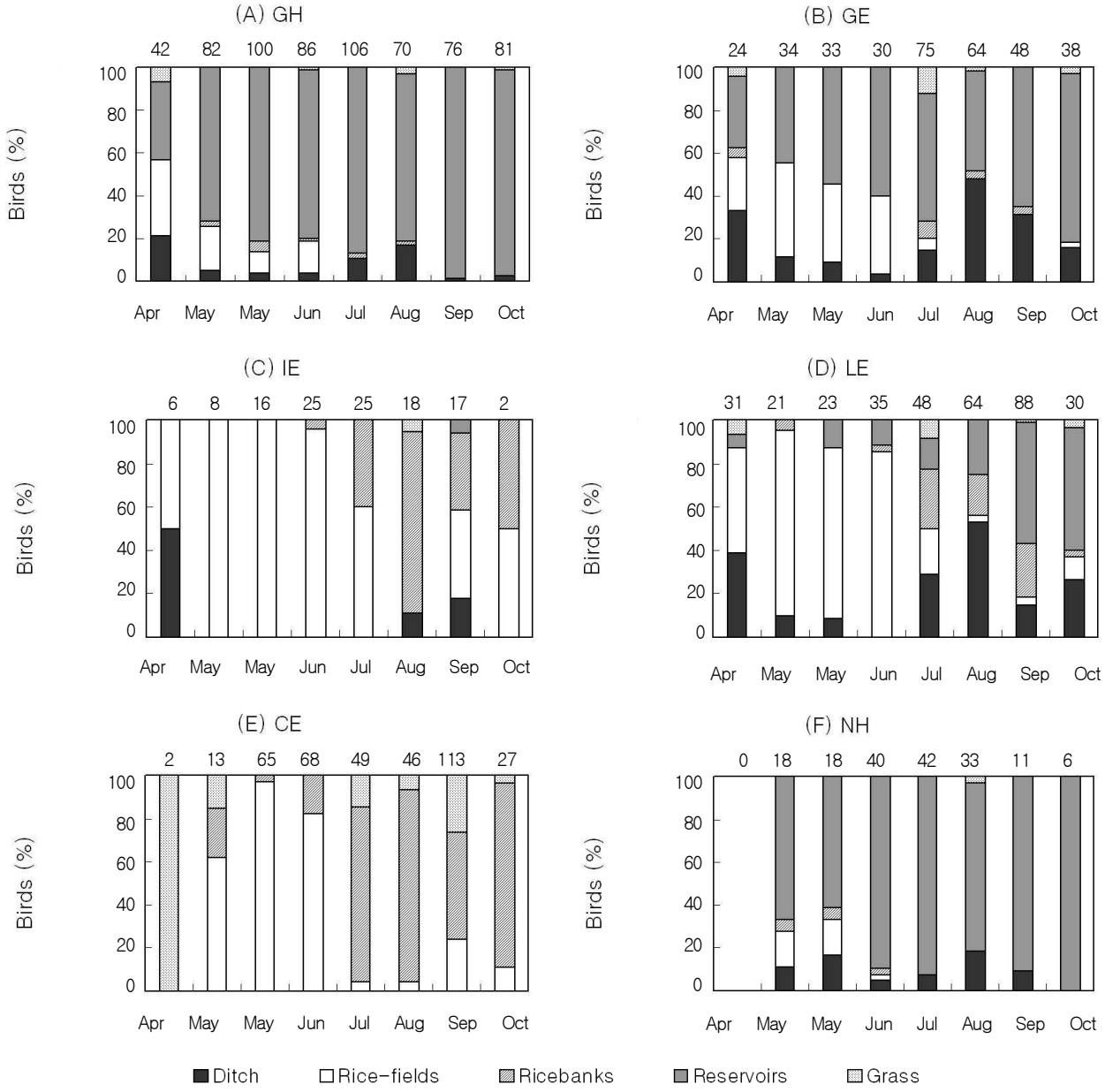

Fig. 4. Monthly changes in feeding habitat selection of grey herons (A), great egrets (B), intermediate egrets (C), little egrets (D), cattle egrets (E), and black-crowned night herons (F). Figures above bars indicate the numbers of feeding birds.

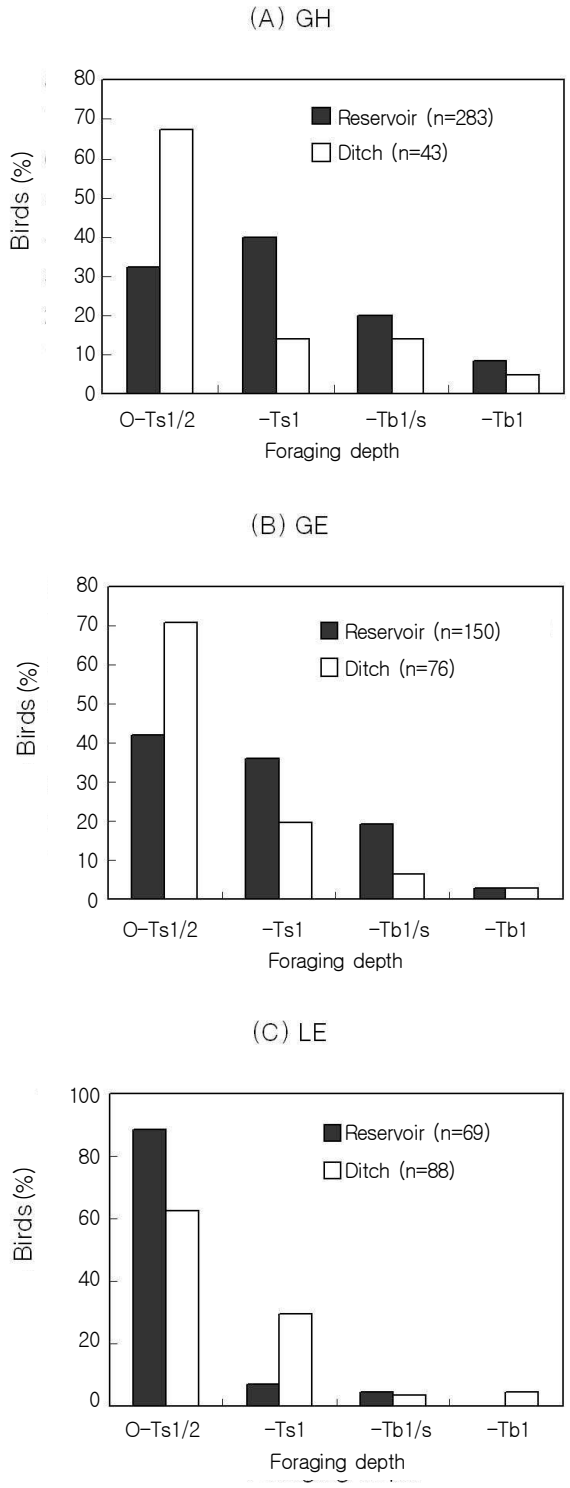

Fig. 5. Foraging water depths of grey herons (A), great egrets (B), and little egrets (C) in reservoirs and ditches.

the length of the tarsus. In addition, grey herons primarily hunted large fishes in reservoirs, whereas the great egret preyed upon somewhat smaller prey in ditches as well as reservoirs (Choi YS and Kwon IK, personal communications). Two rice-field-dependent species, intermediate and cattle egrets, also differed in their choices of prey and feeding methods (Choi YS, unpublished data). The little egret is a habitat generalist that can forage in various habitats (Hafner et al. 1986, Tojo 1996, Dimalexis et al. 1997, Wong et al. 1999). Black-crowned night herons were more often observed in reservoirs than in rice fields. However, their nocturnal and cryptic feeding habits made it difficult to determine their primary feeding habitat (Voskamp and Zoetebier 1999) and our study methods were also somewhat inadequate for this species (Lane and Fujioka 1998).

In the present study, all species displayed seasonal changes in feeding habitat use, which is related to changes in the availability of feeding habitats. Feeding in rice fields was observed more frequently in May～June for most species than from July～September. Moreover, most feeding individuals preferred rice banks (or levees) or edge areas and avoided the inner parts of rice fields from July～September. Rice fields systems showed seasonal changes in field conditions; the rice crop developed gradually, and fields transitioned from open water in April～May to densely vegetated habitat after July. It is difficult to spot prey in densely vegetated rice fields, which may encourage herons to change their feeding sites or methods (Maeda 2001, Richardson et al. 2001). In the periods when rice fields were covered with dense vegetation, rice banks provided vegetation gaps suitable for birds foraging on aquatic prey (Sato and Maruyama 1996, Maeda 2001). Also, when water levels are high, reservoirs are unavailable to some birds and foraging habitat is generally restricted to a narrow band of edge (Powell 1987, David 1994). In our study area, during the early part of the breeding season (April～early May) the water level was normally high in reservoirs and thereafter declined gradually as water was provided to rice fields. In our study, the little egret was present in the rice fields during the early part of the season, but they shifted to various other habitats, particularly reservoirs, during the later part of the season.

In conclusion, it appears likely that each heron species has avoided competition for limiting resources by selecting different habitats or microhabitats and also that they make seasonal adjustments to their habitat preferences in response to changes in the availability of feeding habitats. The present study suggested that rice fields provide valuable feeding habitats for herons and egrets. However, rice fields may not be equally suitable in all regions, as crop development and local water conditions may affect ardeid feeding efficiencies in rice fields.

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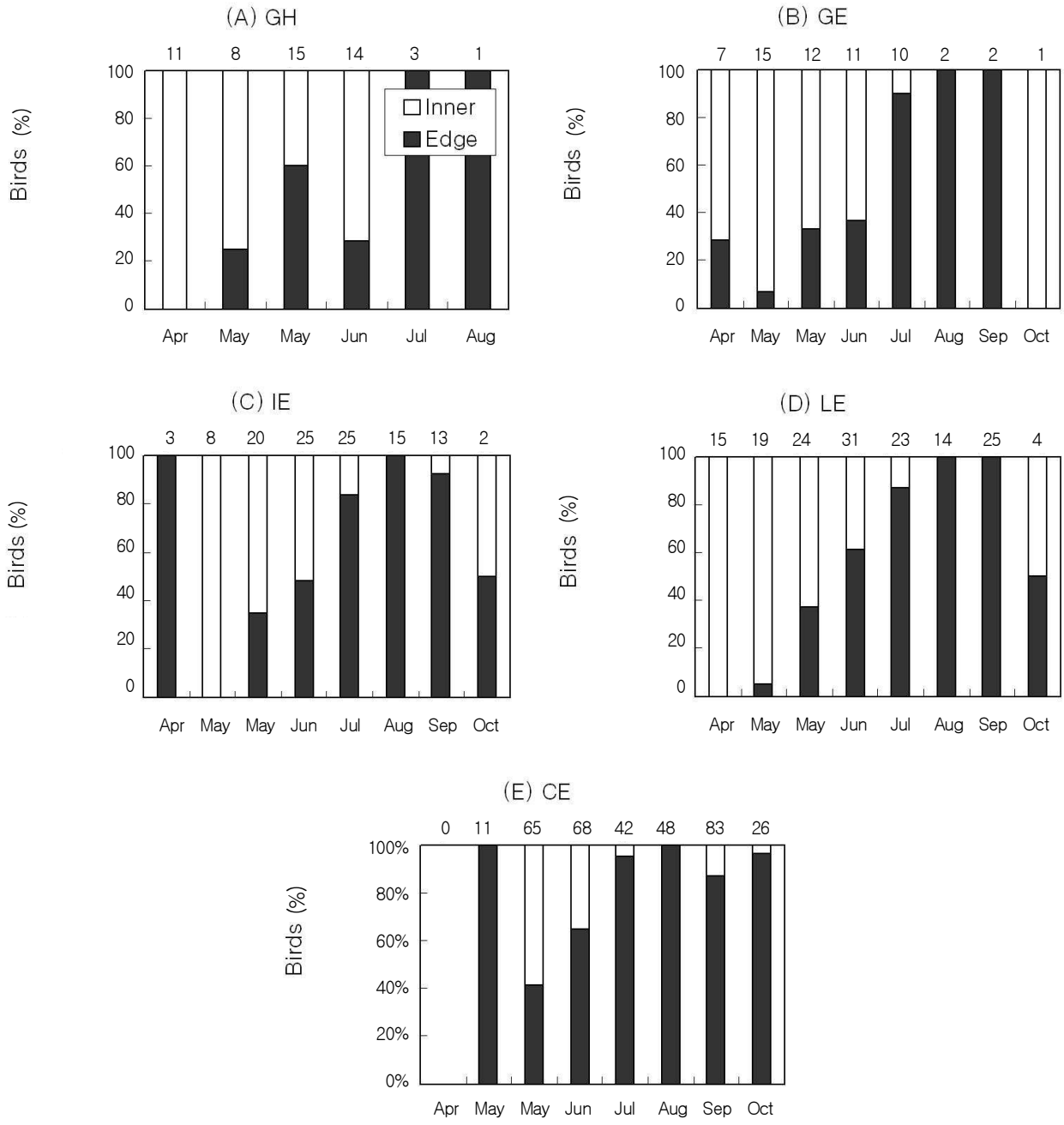

Fig. 6. Feeding site selection of herons and egrets in rice fields (interior areas vs. edges, including rice banks). GH: grey herons, GE: great egrets, IE: intermediate egrets, LE: little egrets, CE: cattle egrets. Figures above bars indicate the numbers of feeding birds.

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