JOURNAL OF
ECOLOGY AND ENVIRONMENT
http://www.jecoenv.org

Research Paper
J. Ecol. Environ. 36(4): 211-216, 2013

Distribution and abundance of wintering raptors in the Korean peninsula

Sangdon Lee*

Ecological Restoration Engineering Laboratory, Department of Environmental Science and Engineering, Ewha Womans University, Seoul120-750, Korea

Abstract

The purpose of this study is to examine distribution and abundance of wintering raptors in Korea during 2000-2007 which is a rare data set for covering large landscape areas. Total 6,643 raptors of 16 species were recorded at 94 different points in west, south and east coasts, and rivers of inland areas all over Korea. During the study period, the most abundant raptors were black vulture (*Aegypius monachus,* 62.3%), common kestrel (*Falco tinnunculus*, 11.0%) and common buzzard (*Buteo buteo,* 10.0%), and these 3 birds were dominant species in inland areas and also considered as resident species except for black vulture. Also, there was a difference among 5 different habitat types. Black vultures were most found in estuaries whereas common buzzard and common kestrel could be found in coastal areas. Presumably raptors prefer reservoirs and estuaries probably due to lower human disturbance in these areas, and management efforts should be concentrated in inland areas for black vulture and coastal areas for common kestrel and common buzzard.

Key words: black vulture, conservation, landscape, Whitaker's measure, wintering raptors

INTRODUCTION

Studies on the distribution and abundance of raptors are rarely conducted in the Republic of Korea (ROK). However, the importance of raptors in conservation comes from several conceptual qualities. Firstly, raptors are considered as an umbrella species with low population densities and large individual home ranges so that most raptors are indicative to change in natural ecosystem. Secondly, they can act as valuable indicator species on changes and stresses in ecosystems, as they are quite sensitive to changes in habitat structure and fragmentation and have a high susceptibility to local extinctions (Simberloff 1998). Thirdly, conservation efforts can be more efficient when oriented to flagship species like raptors (Simberloff 1998, Sergio et al. 2005). Currently no assessment has been made in the distribution and abundance of raptors in ROK which hampers understanding their ecology and habitat usage and efficient conservation on raptors.

I assume that main causes of threat to raptors in ROK are anthropogenic factors such as reclamation, rapid urbanization, and intensive agriculture. Different types of landscape alterations may have different effects on raptor populations, depending on the type and intensity of disturbance, and on the characteristics of the species involved (Palomino and Carrascal 2007). Detrimental impacts on raptors have been documented as a result of habitat loss and fragmentation (Thiollay and Rahman 2002) and direct disturbance derived from human presence and associated infrastructure (Zelenak and Rotella 1997).

Most urbanized areas on the Korean peninsula are

http://dx.doi.org/10.5141/ecoenv.2013.211

Received 14 May 2013, **Accepted** 12 November 2013

***Corresponding Author**
E-mail: lsd@ewha.ac.kr
Tel: +82-2-3277-3545

located along or near the highly indented western and southern coasts, where numerous fishing villages and vast tidal flats are well developed. In contrast, the peninsula's eastern seaboard is generally uniform with extensive underdeveloped coastlines. Most of the mountainous terrain is located north, where there are few arable (farmable) plains. The few remaining dense forests are located in the far north. In this study we aimed to define distribution and abundance of raptor species which occur in different habitats and to explain it referring to the environmental factors in those habitats.

MATERIALS AND METHODS

Contemporary count data were used from a wintering bird census coordinated by the National Institute of Environmental Research (NIER, http://www.nier.go.kr). The NIER census was started in 1999 and entails an annual one-day count in January (or early February) of all bird species by site with results then published by the National Ministry of Environment of Korea. The annual NIER Census Reports of 1999, 2004, 2005, 2006 and 2007 listed the abundance of all bird species recorded by site, with 56 sites covered in 1999 increasing to 128 sites counted in 2007. Analysis was focused on 94 sites that were surveyed in all the years because of data differences.

In the absence of a complete methodology, the NIER census reports provide the best data for establishing current habitat usage of wintering birds in ROK (Moores et al. 2010). Although NIER census reports also have limited value for developing national population estimates or identifying population trends especially of shy or localized birds, preliminary analysis indicates that the data do reveal population trends in several more widespread and easy-to-identify species at the national level (Moores et al. 2010).

Based on the description of sites, study areas were divided into 5 habitat types; coasts, coastal lake/reclaimed areas, rivers, estuaries and reservoirs (e.g., dam lakes). For statistical analysis, 16 raptor species, which were recorded at least 5 times during the 8-year annual census, were chosen as study species. Relative abundance of the raptor species were calculated annually and spatially and dynamics of the abundance over time were estimated using linear regression.

In order to compare the rate of changes in raptor community per sites across regions, I estimated regional diversity indices for inland region which comprised of 28 count sites, for west coast with 27 sites, for south coast with 24 sites and for east coast with 15 sites by calculating Beta diversity index or Whittaker's measure as follows:

$\beta = S/\alpha - 1$, where S is the number of species in the entire set of sites and α is the average number of species per sites.

The lower values indicate a homogeneous landscape with respect to particular environmental factor while higher values (no upper limit, but empirical values above 10 are rare) indicate heterogeneous landscape characterized with various factors (Van Dyke 2008).

RESULTS

A total of 6,643 individuals from 16 species were recorded at 94 count sites all over Korea from 2000-2007. Among 16 raptor species, 13 species were from family Accipitridae and remaining 3 species were from family Falconidae (Appendix 1). Five species were resident birds including Common Buzzard (*Buteo buteo),* Eurasian Sparrow Hawk (*Accipiter nisus*), Golden Eagle (*Aquila chrysaetos),* Peregrine Falcon (*Falco peregrines*), and Common Kestrel (*F. tinnunculus*) and comprised 24.7% of the total individuals. Seven species were wintering birds: Black Kite (*Milvus migrans*), Black Vulture (*Aegypius monachus*), Northern Goshawk (*Accipiter gentilis),* Rough-legged Buzzard (*B. lagopus*), Merlin (*F. columbarius),* Upland Buzzard (*B. hemilasius)* and Steller's Sea Eagle (*Haliaeetus pelagicus*), and comprised 66.9% of the total individuals (Table 1). The most abundant raptors were Black Vulture (62.3%), Common Kestrel (11.0%), and Common Buzzard (10.0%). Years with numerous raptors were 2005 with 1,773 individuals, and 2006 with 1,291 individuals (Fig. 1).

Wintering raptor species showed high fluctuation in abundance (Fig. 2). A sudden increase of wintering raptors during 2005 and 2006 seems to be due to that of Black Vulture. Great flocks of the Black Vulture were found in 2005 in the estuary of Imjin River (1,123 individuals) and in 2006 at Cholwon plain (604 individuals). Those areas are both located in the northern part of ROK and a borderline of DMZ (Demilitarized Zone) where the forested mountains and relatively undisturbed landscapes dominate.

According to the result of regression analysis on relative abundances of species by years, the Black Vulture (r^2 = 0.60, P = 0.02) and Peregrine Falcon (r^2 = 0.57, P = 0.03) have been increasing while the Pied Harrier (r^2 = 0.54, P = 0.04) has been decreasing in abundance among 16 raptor species during study periods (Fig. 3).

This implied that there are differences in abundance

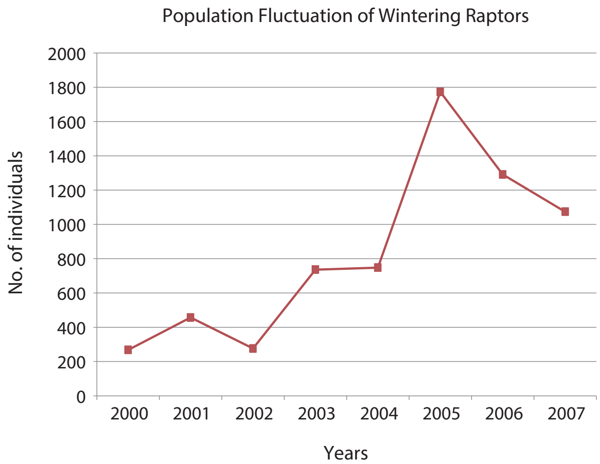

Fig. 1. Annual population trend of 16 raptor species found in 94 sites. The highest number of raptors was recorded in 2005 whereas the lowest numbers were recorded in 2000 with 268 individuals and in 2002 with 276 individuals.

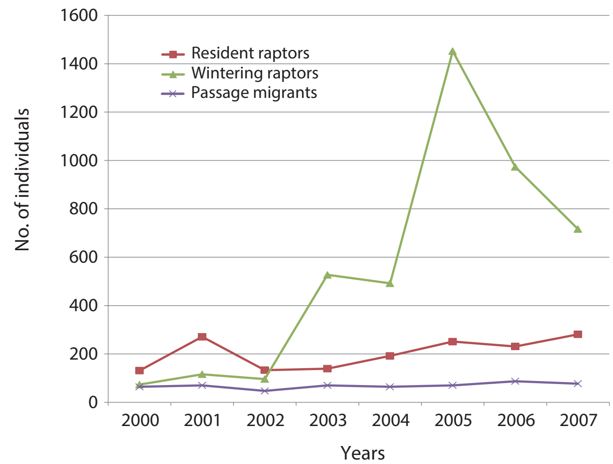

Fig. 2. Population dynamics of wintering raptors by migratory types. Wintering raptors were less stable in abundance than resident and passage migrants. Their numbers were mainly influenced by changes in abundance of Black Vultures since 2002.

depending on habitat types (Table 1). For instance, in estuaries areas the dominant species was Black Vulture ($\bar{x}$ = 323.8 individuals/site) whereas in coastal lakes the dominant species were Common Kestrel ($\bar{x}$ = 11.59).

On average, the abundance of raptors in reservoirs ($\bar{x}$ = 116.83) and estuaries ($\bar{x}$ = 399.8) were higher than those in coastal lakes ($\bar{x}$ = 37.04), coasts ($\bar{x}$ = 21.39) and rivers ($\bar{x}$ = 36.4) (P = 0.00) (Table 1). Within coastal areas, raptor abundances in the west ($\bar{x}$ = 8.42) and south ($\bar{x}$ = 6.31) coasts were higher than that in the east coast ($\bar{x}$ = 1.51) (data not shown) (P = 0.00).

Table 1. Summary of relative abundances of mean by each species at 5 different habitats

Species			Habitats					
Common Name	*Code*	*Wintering/ Resident*	*Coast (36 sites)*	*Coastal lakes (22 sites)*	*Rivers (7 sites)*	*Estuaries (5 sites)*	*Reservoir (24 sites)*	*Total (94 sites)*
Family Accipitridae								
Osprey	PAHA	-	3.03	0.50	0.00	7.00	0.08	157
Black Kite	MIMI	○	0.17	0.09	3.86	25.00	0.29	167
White-tailed Eagle	HAAL	○	0.94	2.23	1.43	4.40	2.17	167
Steller's Sea Eagle	HAPE	○	0.17	0.18	0.14	1.00	0.13	19
Northern Goshawk	ACGE	○	0.11	0.73	0.00	0.60	0.50	35
Eurasian Sparrow Hawk	ACNI	●	0.58	0.73	0.43	0.80	0.38	53
Rough-legged Buzzard	BULA	○	0.17	0.36	0.00	0.40	0.29	23
Upland Buzzard	BUHE	○	0.11	0.45	0.57	0.60	0.21	26
Common Buzzard	BUBU	●	5.33	9.00	6.57	15.60	6.25	664
Golden Eagle	AQCH	●	0.86	1.59	0.86	1.80	1.42	115
Black Vulture	AEMO	○	1.86	1.18	9.86	323.80	98.13	4136
Hen Harrier	CICY	-	0.50	6.59	1.86	4.80	1.04	225
Pied Harrier	CIME	-	0.06	0.23	0.00	0.00	0.00	7
Family Falconidae								
Peregrine Falcon	FAPE	●	1.25	0.91	0.29	1.60	0.21	80
Merlin	FACO	○	0.31	0.68	0.29	0.40	0.42	40
Common Kestrel	FATI	●	5.94	11.59	10.29	12.00	5.33	729
Total			770	815	255	1999	2804	6643

Annual relative abundances of species were calculated by each different habitat types. Note: ○ indicates wintering raptor species, ● indicates resident, and '–' is passage migrants. Latin name of species were written (see Appendix 1).

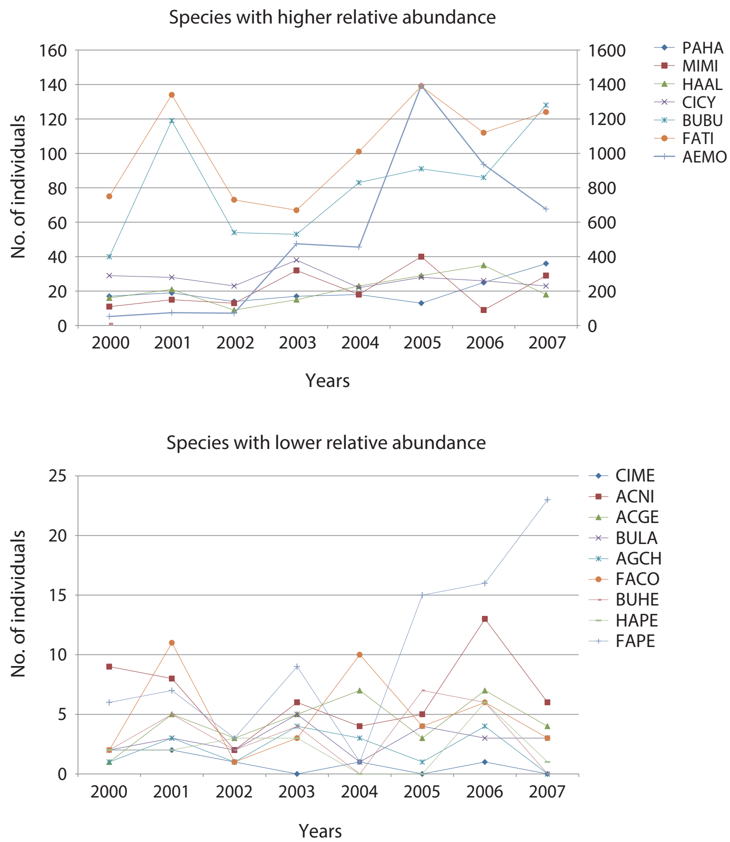

Fig. 3. Relative abundances of each raptor species plotted by years and number of individuals. Primary vertical axis (left side) shows the number of individuals for the all raptor species except for the Black Vulture (*Aegypius monachus*, AEMO) which was plotted separately on the secondary vertical axis (right side) due to its much higher abundance. Four letter codes for each species were explained in Appendix 1.

Regional Biodiversity

The value of the beta diversity index was 4.96 for the south coast, 5.1 for the west coast, 5.25 for east coast and 6.43 for the inland region. These values can simply demonstrate that coastal regions have small rate of changes in raptor species composition and are considered as homogenous landscapes with respect to particular environmental variables. On the other hand, inland regions might be heterogeneous landscapes characterized by various environmental factors and have greater rate of change in the raptor community across its sites because of the higher beta index value.

DISCUSSION

The purpose of the study was to define the distribution and abundance of raptor species in different habitats of the Korean peninsula and to explain them in relation to environmental factors in those habitats.

Among all raptors counted, wintering raptors were in the majority (67.2%), and they were not stable in abundance between the study years (Fig. 1). The sudden increase of Black Vulture abundance in 2005 and 2006 is related to their increase in total population (Fig 3). In the inland part of Korea such as Cholwon started to provide winter feeding program targeting to Black Vulture due to its status of Natural Monument (#243) in Korea (http://www.cha.go.kr). Similarly increase in relative abundance was observed with other waterfowl birds such as Baikal Teal (*Anas querquedula*), mallard (*A. platyrhynchos*), and White-fronted goose (*Anser albifrons)* which are increasing greatly in abundance due to reclamation of land into agricultural land (NIER 2007).

Coastal habitats and biodiversity are threatened by land reclamation in Korea (Kim et al. 2003). The fact that twice as many raptors were found in inland areas than coastal areas indicates that coastal regions are suffering from the pressure of land reclamation, farming, urbanization and industrialization (Table 1). In this study, Common Kestrel and Common Buzzard were dominant species in coastal areas including habitats such as coasts, coastal estuaries, and reservoirs/reclaimed areas. The same result has been found in the surveys in agricultural areas of eastern Kazakhstan and it was suggested that transformation of the natural habitats into agricultural land has some positive effect for small to medium-sized raptors by increasing small rodents (Sanchez-Zapata et al. 2003). Besides it has been noted that some raptors such as Common Buzzard favor habitats with other open lands, and avoid poor homogeneous habitats (Bustamante and Seoane 2004, Palomino and Carrascal 2007).

It appeared that habitat use of resident raptor species was also driven by other historical or evolutionary factors. Resident raptor species such as Common Buzzard, Common Kestrel in this study had much higher abundance in the coast and coastal regions (Table 1). This might suggest that occupancy pattern of a species be partially driven by historical reasons, intraspecific and interspecific interactions. It might be possible that resident birds have better adapted to inland areas which are more familiar with for settlement during breeding and survival. Furthermore it becomes clear that the water channels and reservoirs set up for farming purposes support some water birds in wetlands and birds of prey use rice paddies to chase and capture ducks and small rodents for food (Kim et al. 2003, Legendre et al. 2002). Coastal area also showed the lower value of Whitaker measure presumably indicating that birds in the coastal areas are evenly distributed than in inland areas. On the other hand, higher beta index of inland regions suggest that inland regions might provide heterogeneous landscapes characterized by various environmental factors and have greater rate of change in the raptor community across the sites (Van Dyke 2008).

Large scale modification of inland streams and wetland areas into reservoirs and dams could have negative impacts on biodiversity including water birds, fishes etc., due to seasonal water level change from flooding, temperature and oxygen in deep water, summer monsoon effects, and also reservoirs maybe colonized by species which are a vector of human and animal diseases (Kim et al. 2000).

In conclusion, this study revealed spatial and temporal patterns in the abundance of raptors in ROK. The data from the NIER census are a large set data and cover most landscape areas in Korea so that population monitoring could require time and large number of people. This study, therefore, is the first to provide scientific evidence on population changes in raptors over the past 8 years in ROK. The results provide an important basis for taking appropriate conservation measures and improving the quality and quantity of nationwide surveys of birds of prey.

ACKNOWLEDGMENTS

The authors wish to thank NRF (2009-1419-6), Ewha Global Top 5 Grant (2013) and KEITI (403-112-005) for financial support. Dr. Amano and Ms. Sonor Altjin provided comments on the early draft of the manuscript.

LITERATURE CITED

Bustamante J, Seoane J. 2004. Predicting the distribution of four species of raptors (Aves: Accipitridae) in southern Spain: statistical models work better than existing maps. J Biogeogr 31: 295-306.

Kim B, Choi K, Kim C, Lee UH, Kim YH. 2000. Effects of the summer monsoon on the distribution and loading of organic carbon in a deep reservoir, lake Soyang, Korea. Water Res 34: 3495-3504.

Kim JH, Yoo BH, Won C, Park JY, Yi JY. 2003. An agricultural habitat indicator for wildlife. In: Agriculture and Biodiversity: Developing Indicators for Policy Analysis; Proceedings from an OECD Expert Meeting, Zurich, Switzeland, November 2001. OECD Publishing, pp 94-104.

Legendre P, Dale MRT, Fortin MJ, Gurevitch J, Hohn M, Myers D. 2002. The consequences of spatial structure for the design and analysis of ecological field surveys. Ecography 25: 601-615.

Moores N, Kim A, Park MN, Kim SA. 2010. The anticipated impacts of the four rivers project (Republic of Korea) on waterbirds. Birds Korea Preliminary Report. Birds Korea.

NIER 2007. Contemporary census of wintering bird Korea. NIER, Inchoen.

Palomino D, Carrascal LM. 2007. Habitat associations of araptor community in a mosaic landscape of central Spainunder urban development. Landsc Urban Plan 83: 268-274.

Sanchez-Zapata JA, Carrete M, Graviliov A, Sklyarenko S, Ceballos O, Donazar AJ, Hiraldo F. 2003. Land use changes and raptor conservation in steppe habitats of eastern Kazakhstan. Biol Conserv 111: 71-77.

Sergio F, Newton I, Marchesi L. 2005. Conservation:top predators and biodiversity. Nature 436: 192.

Simberloff D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era?.

Biol Conserv 83: 247-258.
Thiollay JM, Rahman Z. 2002. The raptor community of central Sulawesi: habitat selection and conservation status. Biol Conserv 107: 111-122.
Van Dyke F. 2008. Conservation biology: foundations, concepts, applications. 2nd ed. Dordrecht, Springer.
Zelenak JR, Rotella JJ. 1997. Nest success and productivity of Ferruginous hawks in northern Montana. Can J Zool 75: 1035-1041.

Appendix 1. Family, common name and scientific name of species used in this study

Scientific Name	Common Name	Code	Migratory Types
Family ACCIPITRIDAE			
Pandion haliatus	Osprey	PAHA	Passage migrant
Milvus migrans	Black Kite	MIMI	Wintering
Haliaeetus albicilla	White-tailed sea eagle	HAAL	Passage migrant
Haliaeetus pelagicus	Steller's sea eagle	HAPE	Wintering
Accipiter gentilis	Northern Goshawk	ACGE	Wintering
Accipiter nisus	Eurasian Sparrow Hawk	ACNI	Resident
Buteo lagopus	Rough-legged Buzzard	BULA	Wintering
Buteo hemilasius	Upland Buzzard	BUHE	Wintering
Buteo buteo	Common Buzzard	BUBU	Resident
Aguila chrysaetos	Golden Eagle	AQCH	Resident
Aegypius monachus	Black Vulture	AEMO	Wintering
Circus cyaneus	Hen Harrier	CICY	Passage migrant
Circus melanoleucos	Pied Harrier	CIME	Passage migrant
Family FALCONIDAE			
Falco peregrinus	Peregrine Falcon	FAPE	Resident
Falco columbarius	Merlin	FACO	Wintering
Falco tinnunculus	Common Kestrel	FATI	Resident