Characteristics of Bird Community by Types of Habitat in Deogyusan National Park

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Abstract: This study was to analyse on the bird communities of Deogyusan National Park conducted from July 2008 to June 2009, and from April to July, 2010. During the research period, a total of 2,689 individuals were observed, specifically, 12 orders, 34 families and 96 species. The most dominant species was *Passer montanus* (404 individuals, 15.02%), followed by *Paradoxornis webbianus* (156 individuals, 5.80%), *Emberiza elegans* (153 individuals, 5.69%), *Corvus frugilegus* (145 individuals, 5.39%), *Hypsipetes amaurotis* (110 individuals, 4.09%), *Streptopelia orientalis* (106 individuals, 3.94%), *Aegithalos caudatus* (97 individuals, 3.61%), *Cettia diphone* (94 individuals, 3.50%), and *Turdus pallidus* (89 individuals, 3.31%). The largest number of species were observed in May and June, breeding season, and in winter the number was low. The largest number of individuals were also observed in May and June, and the number was also low in fall and early spring. Species diversity was the highest in Baekryunsan area, forest area. Species richness was the highest in Seolcheon area, lowland snow area. Both species diversity and species richness were the lowest in Hyangjeokbong area, mountain ridge. The coefficient of similarity of research areas shows that species composition is dependent on environment. Areas were groups into Hyangjeokbong area (highland ridge), Baekryunsan area and Anseong area (slope and valley), and lowland area and Seolcheon area (farmland and stream).

Keywords: Dominant species, habitat, Species diversity, Species richness, Coefficient of similarity

Introduction

The Korean National Park, as one of the most representative ecological, natural and cultural sites of Korea, includes native plants of the Korean peninsula, the ecological significance of which cannot be emphasized more (Kim, 1993). However, the effective land use and the increase of visitors to the Korean National Park led to the expansion of road construction which on the other hand resulted in the ecological fragmentation and damage of natural habitat (Kim, 1993). While the analysis of 15 national parks revealed that the Jirisan, Seolaksan, Sokrisan, Hanrasan, Deogyusan, Odaesan and the Sobaeksan National Parks are the most valuable ecological sites to be preserved, while at the same time these areas are suffering the high level of disruption caused by visitors (Kim and Nam, 1996).

The Deogyusan National Park (established in February 1, 1975) is located in the central region of the Sobaek Mountains and is an inland mountain area surrounded by Gayasan (Mt.) to the east, Naejangsan (Mt.) to the west, Jirisan (Mt.) to the south and Gyeryongsan (Mt.) and Sokrisan (Mt.) to the north. Its most prominent peak is the Hywangjeokbong (1,614 m), followed by Seolcheonbong (1,510 m), Dumunsan (1,051 m), Jeoksangsan (1,029 m) and Geochilbong (1,177 m) and Jungbong (1,593 m), Muryongsan (1,492 m) and NamDeogyusan (1,507 m) to the south. The park stretches over 231.650 km² of surface area and includes 4 districts, including Jeonrabukdo and Gyeongsangnamdo (Korea National Parks Authority, 2004).

Studies on the avifauna of the Deogyusan National Park included a study by Lee et al. (1994), which reported 34 species of 16 families and 5 orders in its fall and summer study and a study by Lee (2003), which reported 69 species. Furthermore, such studies were conducted through natural resource study of the Deogyusan National Park (Korea National Parks Authority, 2004) and resource monitoring (Korea National Parks Authority, 2008), the studies were generally limited mostly to specific seasons, showing lack of a comprehensive study on the avifauna of the region with regards to individual seasons and habitat types.

Therefore, this study was conducted in order to compare and analyze the avifauna of the Deogyusan National Park in relation to the months and area in order to provide information for effective protective measurement and systematic management of the Deogyusan National Park as an avian habitat.

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Materials and Methods

Study area

The Deogyusan National Park stretches over 2 provinces and 4 districts of Yeongnam and Honam region and was designated as a national park (surface area 231,650 km$^2$) in 1975. A 30 year census, taken between 1971 and 2000, showed annual average temperature of 10.4°C, with the average temperature of 23.1°C in July and August and −1.2°C in February. Annual average precipitation is 1,422.1 mm, with 57% of the total occurring during the summer and 8% during the winter. The Warmth Index (WL) is 85.7°C/month and the Coldness Index (CL) is −20.7°C/month (Korea National Parks Authority, 2004; Kim, 2010).

The Hyangjeokbong peak includes colonies of the Taxus cuspidata and the Abies koreana, and the ridge area includes colonies of the Rhododendron schlippenbachii-Hemerocallis fulva. The ridge area of Hyangjeokbong location 1,500 m above sea level includes the Quercus mongolica colony as the subtrees, with such colonies found in the tree layer of slopes or valley areas. Colonies of the Q. variabilis and the Q. serrata, along with Pinus densiflora colonies primarily in southern slopes and ridge area of the below half, were found in the area between 700 m and 1,000 m above sea level. The valley area included primarily colonies of the Fraxinus mandshurica, while the Chilyeon valley included colonies of the Carpinus laxiflora and the Q. serrata (Korea National Parks Authority, 2004; 2008; Kim, 2010).

In order to assess the avifauna of the Deogyusan National Park, the area was divided into 5 study sites: high-altitude ridge area of the Hyangjeokbong area (A: Seolcheonbong- Hyangjeokbong -Jungbong-Baekambong-Dongyeopryeong), the east slopes valley area of the Baekryunsu area (B: Jungbong- Osujagul-Baekryunsu-Gucheondong Visitors Center), western slopes and valley area of the Anseong area (C: Dongyeopryeong-Anseong Visitors Center), town, road, agricultural area, river streams and reservoir area of the low elevation area (D: Gucheondong and Anseong area under 600 m above sea level), town, road, agricultural area, river streams and reservoir area under 600 m above sea level of the Seolcheon area (E: Gucheondong-Rajaetongmun-Mupung-Eunsanri). The study was conducted over 12 sessions between July of 2008 and June of 2009 and over 4 sessions between April of 2010 and July of 2010, at a total of 16 sessions, on the avian colonies inhabiting the Deogyusan National Park area (Table 1, Fig. 1).

Study methods

The study was conducted using the line transect census method (Bibby et al. 1992) while moving along the hiking trail and roads of the Deogyusan National Park to examine bird community. Birds were observed using a binocular (Nikon 10×50), the naked eye or via bird cries in order to record bird species and individuals, and a GPS (Gamin 60CS) was used to record sites of observation. Observation data was organized by area using volume 25 (Ecosystem of birds) of the Illustrated Encyclopedia of Fauna & Flora of Korea (Won, 1981) and A Field Guide to the Birds of Korea (Lee et al., 2000).

Equations used for the analysis of the avian colonies are as follows.

Relative species density ($RD$) by Brower et al., (1990)

### Table 1. Conditions of survey areas

<table>
<thead>
<tr>
<th>Areas</th>
<th>Distance (km)</th>
<th>Altitude (m)</th>
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<td>&gt;1,300</td>
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<tr>
<td>B</td>
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<td>600–1,500</td>
<td>east slope and valley</td>
</tr>
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<td>C</td>
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<td>600–1,300</td>
<td>west slope and valley</td>
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<td>&lt;600</td>
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<tr>
<td>E</td>
<td>26.8</td>
<td>&lt;600</td>
<td>roadway, village, farmland, stream, reservoir</td>
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</tbody>
</table>

A: Hyangjeokbong, B: Baekryunsu, C: Anseong, D: Lowland, E: Seolcheon
RD = \frac{ni}{N} \times 100

ni: number of individuals at i species
N: total number of individuals

Species diversity (H') by Shannon and Weaver (1949)

\[ H' = -\sum \left( \frac{ni}{N} \times \ln \left( \frac{ni}{N} \right) \right) \]

ni: number of individuals at i species
N: total number of individuals at survey area

Species richness (Da) by Margalef (1963)

\[ Da = \frac{(s-1)}{\ln(N)} \]

s: total number of species
N: total number of individuals at survey area

D (Density) by Bibby et al. (1992)

\[ D = \frac{P}{S} \]

P: higher number of individuals observed in survey area
S: distance of each survey area (Km)

Coefficient of similarity (S) by Sørensen (1948)

\[ S = \frac{2c}{a+b} \]

a: total number of species of site A
b: total number of species of site B
c: number of species observed in both sites A and B

Results

Overall avifauna
A total of 2,689 individuals of 96 species, 24 families and 12 orders were observed in the Deogyusan National Park area during the study period (Appendix 1).

Dominant species included the Passer montanus at 404 individuals (15.02%), followed by, in decreasing order, the Paradoxornis webbianus at 156 individuals (5.80%), Emberiza elegans at 153 individuals (5.69%), Corvus frugilegus at 145 individuals (5.39%), Microscelis amaurotis at 110 individuals (4.09%), Streptopelia orientalis at 106 individuals (3.94%), Aegithalos caudatus at 97 individuals (3.61%), Cettia diphone at 94 individuals (3.50%) and the Turdus pallidus at 89 individuals (3.31%) (Fig. 2).

In terms of the individual months, May of 2010 showed the highest number at 58 species, followed by 53 species in May of 2009 and 52 species in June of 2009, which shows that the highest number of species is found in May and June. On the other hand, February showed the lowest level at 31 species, followed by 32 species in both November of 2008 and January of 2009 and 33 species in October of 2008, which shows that winter is characterized by low number of species. In terms of number of individuals per month, May of 2010 showed the highest count at 1,513 individuals, followed by 1,146 individuals in December of 2008, 1,074 individuals in June of 2010 and 1,039 individuals in September of 2008, which shows that high number of birds were observed in May and June, which are mating season, and September, the preparatory period of birds following the mating season, and the winter season, which is characterized by a high number of winter migratory birds. Months with low number of individuals included October of 2009 at 649 individuals, followed by August of 2009 at 664 individuals, February of 2009 at 683 individuals, November of 2008 at 764 individuals and...
March of 2009 at 758 individuals, and this shows that low number of individuals is associated with fall season following the migrating of summer migratory birds and spring season, which is the time period after the migration winter migratory birds and before the arrival of summer migratory birds (Fig. 3).

Avifauna of individual study sites

Hyangjeokbong area (A: ridge area)
A total of 297 individuals of 34 species were observed in the Hyangjeokbong area during the study period. While the site recorded the lowest number of species and individuals when compared to other study sites, it recorded the 3rd highest Density at 59.4 Ind./km (Table 2).

Dominant species included the Cettia diphone (26.94%), Emberiza elegans (9.76%), Parus ater (8.42%), Leucosticte arctoa (8.08%) and the Parus palustris (5.72%) (Fig. 4). Depending on the environment of the ridge area, which is comprised of sub-alpine vegetation and grassland vegetation, dominant species was the northern bush warbler or the yellow-throated bunting. Furthermore, there was high dominance by the coal tit or the marsh tit, which are small tits, in high altitude regions.

Months of high number of species observed included, in decreasing order, June of 2010 (16 species), June of 2009 (15 species), May of 2010 (15 species) and October of 2008 (14 species), and months of high density included May of 2010 (29.4 Ind./km), July of 2010 (28.0 Ind./km) and June of 2009 (26.4 Ind./km) (Table 2). Overall, between May and July, mating season for permanent residents and summer migratory birds, showed high number of species and Density.

Baekryunsa area (B: eastern slopes and valley area)
A total of 725 individuals of 59 species and density of 71.1 Ind./km were observed in the Baekryunsa area during the study period. The site recorded the 2nd highest number of species, individuals and density when compared to other study sites (Table 2).

Dominant species included the Aegithalos caudatus (8.83%), Paradoxornis webbianus (6.21%), Fringilla montifringilla (6.21%), Phylloscopus coronatus (5.24%) and the Turdus pallidus (4.97%) (Fig. 4). The Brambling, which was recorded as a dominant species, was observed temporarily in a large flock near the Gucheondong Visitors Center in April of 2010, and other dominant species were tree-type and bush-type mountain forest species.

Months of high number of species observed included, in decreasing order, May of 2010 (36 species), July of 2010 (35 species) and May of 2009 (34 species), and months of high density included May of 2010 (41.5 Ind./km), May of 2009 (31.9 Ind./km) and April of 2009 (29.5 Ind./km) (Table 2). Overall, between May and July, mating season for permanent residents and summer migratory birds, showed high number of species, while April and May observed high Density.

Anseong area (C: western slopes and valley area)
A total of 346 individuals of 44 species were observed in the Anseong area during the study period. The site recorded the 4th lowest number of species and individuals, but recorded the highest level of Density at 76.9 Ind./km (Table 2).

Dominant species included the Aegithalos caudatus (14.74%), Paradoxornis webbianus (8.09%), Emberiza elegans (7.51%), Phylloscopus coronatus (5.20%) and the Sitta europaea (5.20%) (Fig. 4). The majority of the dominant species recorded were tree-type and bush-type mountain forest species.

Months of high number of species observed included, in decreasing order, May of 2009 (29 species), June of 2010 (26 species) and June of 2009 (25 species), and months of high density included April of 2010 (41.1 Ind./km), May of 2009 (33.6 Ind./km) and May of 2010 (32.9 Ind./km) (Table 2). Overall, May and June, mating season for permanent residents and summer migratory birds, showed high number of species, while April and May observed high Density.

Low elevation area (D: Surrounding areas of the Gucheondong and Anseong)
A total of 629 individuals of 55 species were observed in the low elevation area during the study period. The site recorded the 3rd highest number of species and individuals, and recorded the lowest level of Density at 33.8 Ind./km (Table 2).

Dominant species included the Passer montanus (24.04%), Streptopelia orientalis (13.22%), Turdus naumanni eunomus (10.03%), Paradoxornis webbianus (8.76%) and the Cyanopic a cyana (4.94%) (Fig. 4). The majority of the dominant species recorded were species which inhabit low altitude agricultural ground or nearby shrubs and grasslands.

Months of high number of species observed included, in decreasing order, May of 2010 (29 species), May of 2009 (26 species) and June of 2010 (23 species), and months of high density included May of 2010 (17.5 Ind./km), January of 2009 (15.8 Ind./km) and December of 2008 (15.8 Ind./km) (Table 2). Overall, May and June, mating season for permanent residents and summer migratory birds, showed high number of species, while May and the winter months of December and January observed high Density. The low elevation area, which includes primarily river streams and agricultural grounds, attracts high number of the dusky thrush and other winter migratory birds, which leads to high Density.
Seolcheon area (E: Surrounding areas of the Seolcheon)

A total of 1,427 individuals of 71 species were observed in the Seolcheon area during the study period. The site recorded the highest number of species and individuals, but recorded the 4th highest level of Density at 53.2 Ind./km (Table 2).

Dominant species included the *Passer montanus* (22.85%), *Corvus frugilegus* (10.16%), *Emberiza elegans* (8.62%), *Paradoxornis webbianus* (7.50%), *Carduelis sinica* (5.26%) and the *Emberiza rustica* (4.91%) (Fig. 4).

The rook was observed in high numbers while wintering in December of 2008 and January of 2009 in agricultural grounds near the Rajaetongmun, and dominant species included primarily species which live in lowland agricultural grounds and nearby shrubs.

Months of high number of species observed included, in decreasing order, May of 2010 (45 species), May of 2009 (39 species) and June of 2009 (39 species), and months of high density included December of 2008 (26.1 Ind./km), September of 2008 (18.9 Ind./km) and January of 2009 (18.9 Ind./km) (Table 2). Overall, May and June, mating season for permanent residents and summer migratory birds, showed high number of species, while September and the winter months of December and January observed high Density. The low elevation area, which includes primarily river streams and agricultural grounds, attracts high number of the rustic bunting and the rook and other winter migratory birds, which leads to high individuals and Density.

Species diversity of bird community by study site

Table 3 summarizes the species diversity index, which increases with increase in the number of species and evenness in distribution, and the species richness index, which increases with increase in the number of species and decrease in individuals.

The Hyangjeokbong area (A) showed the lowest level of the average species diversity at 1.72 (between 1.15 and 2.41) and the Baekryunsan area (B) showed the highest level of the average species diversity at 2.73 (between 2.00 and 3.11). The Anseong area (C) showed the average species diversity of 2.46 (between 1.98 and 2.95) while the low elevation area (D) showed 2.10 (between 1.83 and 2.40). The Seolcheon area (E) showed the 2nd highest level of the average species diversity at 2.47 (between 1.52 and 2.88) ($F_{(4, 75)}=12.949, p<0.001$).

In terms of the changes in the species diversity in regards to months, the high altitude ridge area of the Hyangjeokbong area showed high species diversity in April, May, June, October and January and low species diversity in February, March and July. The valley and mountain forest area of the Baekryunsan and the Anseong regions showed high species diversity in spring (between March and May) and summer (between June and August) and low species diversity in winter (between December and February). On the other hand, the low elevation area and the Seolcheon area showed high species diversity between April and June and low species diversity in winter (January and February), and such findings display regional difference in species diversity.

In terms of the species richness, the Hyangjeokbong area showed the lowest average species richness at 2.11 (between 1.08 and 3.40) and the Baekryunsan area (B) showed the 2nd highest average species richness at 4.51 (between 2.67 and 6.02). The Anseong area (C) showed the average species richness of 3.47 (between 1.88 and 5.58) while the low elevation area (D) showed 3.24 (between...
The Seolcheon area (E) showed the highest average species richness at 4.58 (between 3.21 and 7.15) ($F_{(4,57)}=16.249, p<0.001$).

In terms of the changes in the species richness in regards to months, the high altitude ridge area of the Hyangjeokbong area showed high species richness in April, May, June, October and January and low species richness between December and February. The Baekyeonsa and the Anseong regions showed high species richness between April and June and low species richness in winter (between December and February). The low elevation area and the Seolcheon area also showed high species richness between April and June and low species richness during other months. These findings show that the species diversity and...
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Species richness of the avifauna of the Deogyusan National Park are high during the mating season of between April and June.

Regional coefficient of similarity
Comparison of the Coefficient of similarity of the 5 study sites of the Deogyusan National Park showed high Coefficient of similarity of 0.78 for both the Baekryunsan-Anseong area and the lowland-Seolcheon area. The Hyangjeokbong area showed higher Coefficient of similarity with the Baekryunsan (0.60) and the Anseong area (0.67) than with the lowland (0.47) and the Seolcheon area (0.48) (Table 4). Therefore, the Deogyusan National Park is divided into 3 environments: the high altitude ridge environment of the Hyangjeokbong area (A), the slopes and valley environment of the Baekryunsan area (B) and the Anseong area (C) and the agricultural grounds and river streams of the low elevation area (D) and the Seolcheon area (E). Furthermore, these findings regarding the Coefficient of similarity also showed that there is a difference in species composition as a result of regional environment differences (Fig. 5).

Discussion
A total of 2,689 individuals of 96 species, 34 families and 12 orders were observed in the Deogyusan National Park area between July of 2008 and July of 2010, over a total of 16 sessions, and the inclusion of findings of studies by Lee et al. (1994), Lee (2003) and the Korea National Parks Authority (2004; 2008) concludes a total of 124 species of 42 families and 14 orders (Appendix 1).
Dominant species of this study included the *Passer montanus, Paradoxornis webbianus, Emberiza elegans* and the *Corvus frugilegus*, which were found in large numbers in grasslands, farmland and near shrubs, and most were found in low altitude agricultural grounds or near river streams. The *Cettia diphone*, was found to colonize high altitude shrubs forests located over 1,300 m above sea level, and the *Aegithalos caudatus* and the *Turdus pallidus* were observed in high density in mountain forests of the valley region.

In terms of the number of species and individuals with regards to months, the figures were high in May and June, the preparatory period before the mating season of summer migratory birds and permanent residents characterized by high levels of coverage in relation to layers. On the other hand, the winter season showed a very low number of species of birds found in mountain forest regions, caused by decreased food supply as a result of snow, and increase in the number of birds in areas with higher food supply level. The observation of higher number of both species and individuals in low altitude when compared to the Agosan area is assessed to be the result of the difference in food supplies caused by the difference in mountain forest structure in regards to altitude (Chae and Park, 2005). Therefore, high mountain forest bird density is observed in low altitude shrubs or agricultural grounds.

The analysis of the 5 study sites of the Deogyusan National Park showed that the Hyangjeokbong area, a high altitude ridge region located over 1,300 m above sea level, observed a low level of both the number of species and individuals when compared to other study sites, and species which prefer grasslands or shrubs, such as the *Cettia diphone, Emberiza elegans* and the *Leucosticte arctica* were observed in high Density. High level of the *Hemerocallis fulva* was found in the ridge area stretching from Hyangjeokbong towards NamDeogyusan, and the site also showed high levels of the Korean Fir and coniferous forest, with *Rhododendron schlippenbachii-Hemerocallis fulva* colonies observed at the peaks of the Hyangjeokbong and Jungbong (Kim, 2010). Therefore, it is predicted that bird species which prefer grasslands or shrubs forests were found in high density in the Hyangjeokbong area as a result of the influence of the mountain forest environment with highly developed shrub layer and short trees. Birds of prey especially require a spacious habitat, such as a wide open land, and between 3 and 5 individual birds of the *Falco subbuteo*, which is a summer migratory species found in grassland and shrub forests in the Jungbong area, were observed hunting insects such as dragonflies.

The Baekryunsa area and the Anseong area, which are slopes-valley area, are areas over 600 m above sea level, with the exception of the ridge area, with dominant species including the *Quercus serrata, Q. variabilis* and the *Carpinus laxiflora*. The valley area is characterized by the dominance of the *Fraxinus mandshurica*, while altitude under 700 m above sea level is characterized by the dominance of the *Pinus densiflora* (Kim, 2010). The area showed higher levels of both number of species and individuals when compared to the Hyangjeokbong area, since the area includes a wide range of forest vegetation, tall trees and ratio of trees with diameter at breast height, and the area displayed dominance by the *Aegithalos caudatus, Paradoxornis webbianus, Phylloscopus coronatus, Turdus pallidus* and the *Sitta europaea*, species which inhabit tree-type forests and bush-type forests.

The low elevation area and the Seolcheon area are areas under 600 m above sea level and includes roads, towns, agricultural grounds, reservoirs and river streams alongside high density of the *Emberiza elegans, Corvus frugilegus, Paradoxornis webbianus, Cyanopica cyanus* and the *Streptopelia orientalis*. Lee et al. (2004) has stated that the majority of mountain forest birds were observed in areas connecting forest centers and agricultural ground as a result of the edge effect, and this is related to the finding that the highest number of species were recorded in the Seolcheon area.

In terms of the average species diversity, the Baekryunsa area showed the highest value, followed by the Seolcheon area, Anseong area, low elevation area and the Hyangjeokbong area. Species richness was the highest in the Seolcheon area, followed by the Baekryunsa area, Anseong area, low elevation area and the Hyangjeokbong area. There is limitation to tree growth in high altitude regions, since increase in altitude leads to decrease in habitat (Terborgh, 1973; Rosenzweig, 1992; Rahbek, 1997), decrease in the basal area of the trees caused by decrease in the soil moisture level (Day and Monk, 1974; Lucks et al., 1981; Park et al., 2000) and decrease in temperature. Therefore, it is assessed that the Hyangjeokbong area displays low levels of both species diversity and species richness of birds as a result of low surface area, short trees and low level of vegetation in shrubs and grasslands.

The result of analyzing the 5 study sites of the Deogyusan National Park has revealed differences in the species composition as a result of environmental differences among the high-altitude ridge area of the Hyangjeokbong area, the slopes and valley area of the Baekryunsa-Anseong area and the lowland-Seolcheon area characterized by farmlands and river streams.

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## Appendix 1. List of birds in Deogyusan National Park

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### Order Strigiformes

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### Order Caprimulgiformes

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### Order Aplodiformes

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### Order Coraciiformes

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### Order Piciformes

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**Family Alaudidae**

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### Appendix 1. Continued

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KNPA: Korea National Parks Authority