Original Article

# Bird Diversity and Environmental Correlates in the Mulchat-oream Wetlands of the Jeju Islands, South Korea

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## ABSTRACT

This study was conducted from March 2018 to December 2019 to identify bird diversity and environmental correlates within the Mulchat-oream wetlands in the Jeju Islands of South Korea. A total of 255 individual belonging to 37 species were recorded form Mulchat-oream. The observation produced a species diversity of 3.14, species richness of 6.54 and species evenness of 0.88 in 2018, and in 2019, the observed species diversity was 3.02, species richness was 6.56 and species evenness was 0.84. The highly dominant species are composed of Passeriformes. The absence of diverse submerged plants, deep water depth and isolated geographical locations makes difficult for aquatic birds to prefer this area, and this has resulted in the dominance of Passeriformes. The appearance of the birds was the lowest in the winter and highest during the summer. The analysis showed that the species richness and evenness increased with an increase in temperature and precipitation. However, the number of species appearing during Mulchat-oream significantly dependent on the temperature ($P<0.001$, df=2). To date, there has been little research on bird diversity together with environmental factors for the Hallasan National Park. This study shows the environmental factors and seasonal patterns that affect bird population.

**Keywords:** Bird population, Dominant species, Environment factors, Seasonal patterns, Species diversity

## Introduction

The environment in which organisms live is always changing, and the effect of these changes on the organisms within is highly complex (Nagelkerken & Munday,

2016; Stephens, 1991). In order to clearly understand the effects that environmental changes have on organism, it is therefore necessary to conduct long-term monitoring and analysis so that trends are revealed (Frommolt and Tauchert, 2014; Hashimoto et al., 2020). Environmental factors, including temperature, altitude, precipitation, and solar radiation, are known to affect the habitats of wildlife, including bird species (Martin & Wiebe, 2004; Salewski et al., 2013). In general, birds show various behaviors and preference when choosing their habitat (Fisher & Davis, 2010; Maxwell et al., 2018). For example, forest birds are affected by their physical environment in terms

of temperature and rainfall (Cormont *et al*., 2011; Grinde *et al*., 2017). Thus, wetland conditions, regarding habitats for birds, are characterized by the structure of the wetland, water quality, provision of food and hiding sites, and the presence of predators (Whited *et al*., 2000; Yuan *et al*., 2014). Wetlands also provide productive habitats for aquatic and terrestrial birds as well as wintering grounds for migrating birds (VanRees-Siewert & Dinsmore, 1996).

Many surveys on wetlands and their surrounding areas (Ismail *et al*., 2012; Park, 1990; Rathod *et al*., 2016; Sharma *et al*., 2014) were conducted to better understand the diversity and structure of bird communities, which is necessary to determine the importance of regional or local landscapes for avian conservation (Kattan & Franco, 2004). Changes in species richness, evenness and individual numbers may be used to compare current ecological conditions to previous ones, and they can also be used to predict future ecological conditions (Kim, 2008).

Long-term monitoring studies have been conducted in Jeju Island (Banjade *et al*., 2019; Park, 1990) but only for some areas, and long-term monitoring data is required for other areas where research has not yet been conducted. Various studies have been conducted in Hallasan National Park, and these have focused on bird distribution, habitat information, and population structure (Kim *et al*., 2014; Koh & Kim, 2011). However, the impact that various environmental factors can have not yet been studied.

Hence, we investigate here the relationship between the environmental factors, such as precipitation, temperature and seasons, upon the bird species diversity, richness and evenness in the Mulchat-oream wetlands in Hallasan National Park.

## Materials and Methods

### Study area

The study was conducted at the Mulchat-oream wetlands (E126° 40′ 12.9, N33° 31′ 11.4, alt. 670 m). These are present in a volcanic mountain containing a freshwater Crater Lake at its summit (Fig. 1). This wetland area is protected by law under the Ministry of Environment since it is rich in biodiversity and maintains its primitive nature. In the past, people were permitted to enter, but the natural ecosystem was damaged by human presence and visitors have since been banned. The study site contains diverse flora and fauna, and the plant species are composed of *Carpinus laxiflora Siebold* & *Zucc*, Styrax japonicus Siebold & Zucc, *Quercus serrata Murray* in the upper part and *Sasa quelpaertensis Nakai* in the lower part. The faunal diversity includes *Capreolus pygargus*, *Cervus nippon*, *Sus scrofa* and occasional sighting of *Cervus elaphus*. The International Union for Conservation of Nature red list birds such as *Pitta nympha* and *Terpsiphone atrocaudata* have been frequently observed in the summer.

### Data collection

The field study was carried out from March 2018 to December 2019. Data were collected seasonally in each surveyed year, and on the clear and sunny days, the survey was conducted between 06.00-10.00 hr and from 14.00-18.00 hr to avoid bias caused by the weather conditions. Birds were observed using Olympus binoculars (10×50 DPSI; Olympus, Tokyo, Japan) and were identified to the species level by calls and excrement remnants by using the standard reference book Lee *et al*. (2020). Species were categorized following the reference of the Ornithological Society of Korea (2009) and the National Species List of Korea (National Institute of Biological Resources, 2020). HOBO RX3000-Remote monitoring and a weather station (Onset, Bourne, MA, USA) was set and identified the mean monthly fluctuation on the temperature and precipitation (Fig. 2). During the study period, the data were collected by linking to the HOBO site once a month with a measurement interval of 60 minutes. The average winter temperature during the study period was 1.42°C and the summer temperature was 20.94°C. Seasonal precipitation varied from 238 mm in winter and 977 mm in summer.

### Data analysis

The data were analyzed using a linear analysis. All other procedures were implemented using Excel 2018 (Microsoft, Redmond, WA, USA) and SPSS 20.0 (IBM Co., Armonk, NY, USA). The population index was calculated using the following formula:

◦ Dominance index (Brower *et al*., 1990) : DI : DI=ni/N DI : dominance index, N : total individual, ni : individual of the ith species

◦ Biodiversity index (Shannon & Weaver, 1949) : DH'=-∑{(ni/N) . ln(ni/N)} (ni: species of I' individual, N: total individual)

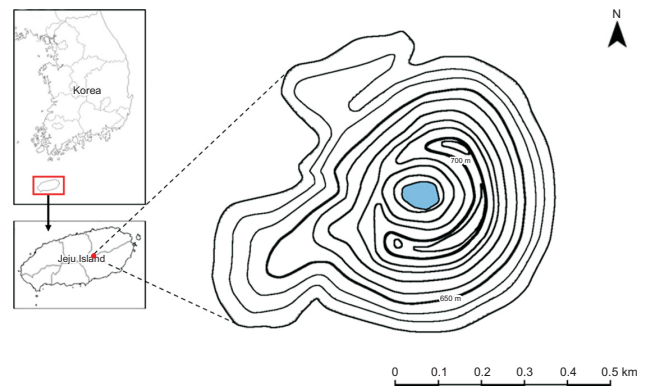◦ Evenness index (Margalef, 1994) : E' E'=D'/Ln (S),



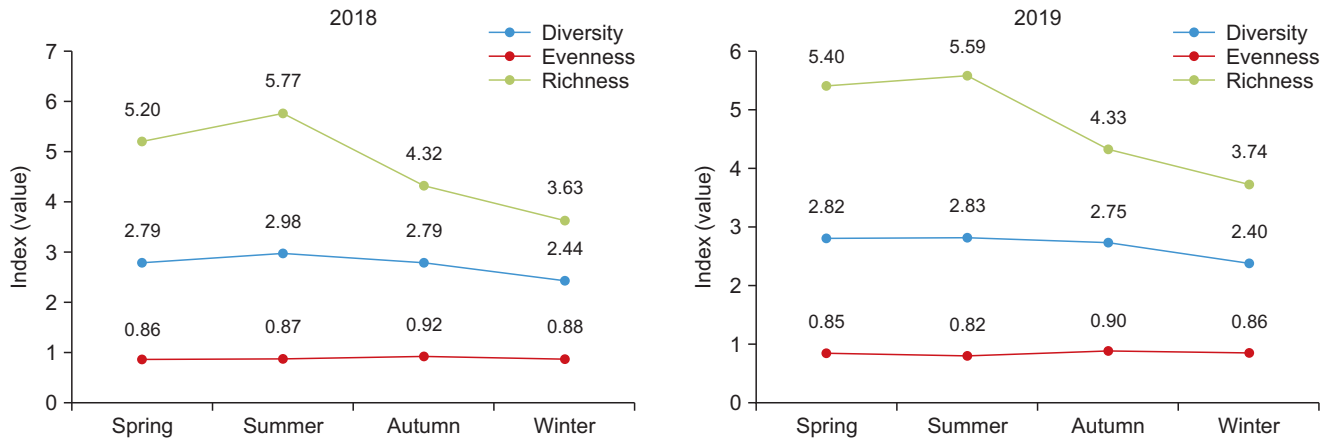**Fig. 1.** The location of study site in Mt. Halla Mulchat-oream on Jeju island.

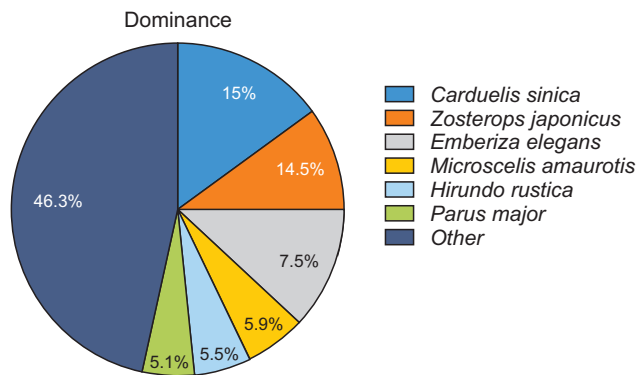**Fig. 2.** Bird diversity value at each season in the study region.



**Fig. 3.** Dominant species by observation on the study site.

E'=evenness, D'=diversity, S: total species
  ○ Richness index : R' R'=(S-1/Ln(n), R'=richness, S: total species, N: total individual

## Results

### Aspect of the entire bird population

A total of 255 individuals of 37 species were recorded in this study. In a 2018 survey, 211 individuals belonging to 36 species were recorded, and in 2019, 242 individuals belonging to 37 species were recorded (Supplementary Table 1). Furthermore, the species diversity was 2.44 to 2.79, species richness was 3.63 to 5.77 and species evenness was 0.86 to 0.92 in 2018. The species diversity was 2.40 to 2.83, species richness was 3.74 to 5.59 and species evenness was 0.82 to 0.90 in 2019 (Fig. 2). The highly dominant species are *Carduelis sinica* (15%) followed by *Zosterops japonicus* (14.50%), *Emberiza elegans* (7.50%), *Microscelis amaurotis* (5.90%), *Hirundo rustica* (5.50%), and *Parus major* (5.10%) (Fig. 3).

### Comparison of the population with weather factors

The average seasonal temperature and precipitation in the Mulchat-oream wetlands compared to the species presence is shown in Figs. 4 and 5. The appearance of the birds was lowest in the winter and highest during the summer (Table 1). The analysis showed that the species richness and evenness increased with an increase in temperature and precipitation (Fig. 6). However, the number of species appearing in the Mulchat-oream wetlands is significantly dependent on the temperature ($P<0.001$, df=2). One notable thing about the precipitation was that the precipitation value in the autumn was higher than the precipitation value in the summer by the LINGLING and TAPAH typhoon.

## Discussion

The opening of forest roads and expansion of trails tends to greatly reduce bird species diversity because trees are eliminated in the area, resulting in simplification of the forest environment (Aleixo, 1999; Thiollay, 1997; 1999). Also, frequent climbing activities can reduce bird population density due to constant interference (Camp & Knight 1998; Covy *et al.*, 2019). Mulchat-oream is restricted to visitors, but travelers usually visit because of the surrounding forest and its connection with the Saryeoni forest trail (Seok *et al.*, 2010). The bird species diversity at Mulchat-oream is generally low compared to that at the Hallasan National Park (Oh, 2002; Park *et al.*, 2011). The occurrence of a lower number of species at the Mulchat-oream wetlands could be attributed to frequent human interference. However, species that prefer the edges of forests or the interior of forests are different, making it difficult to say that human interference has hindered bird inhabitation (Baker *et al.*, 2002; Laiolo & Rolando, 2006). Therefore, it is believed that further investigation is needed to detail the habitat preferences and
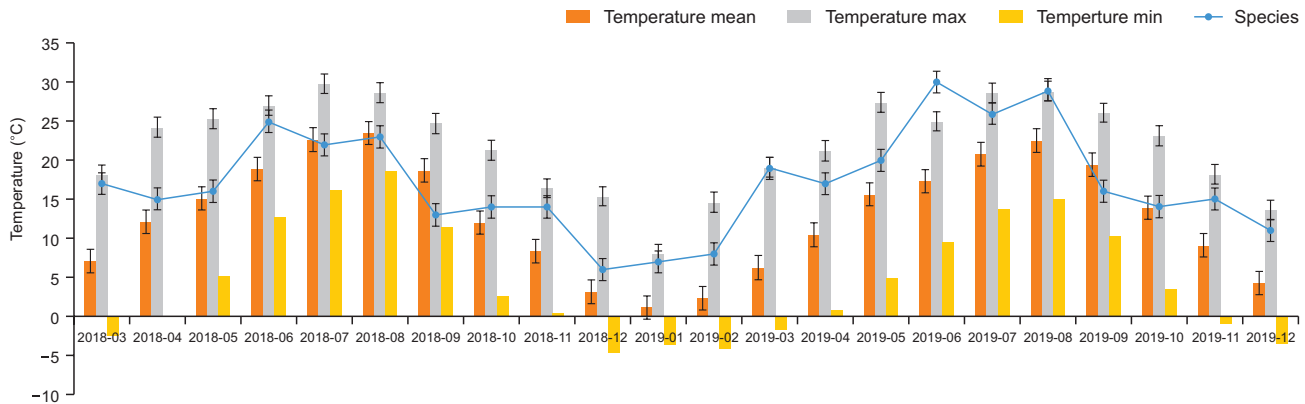
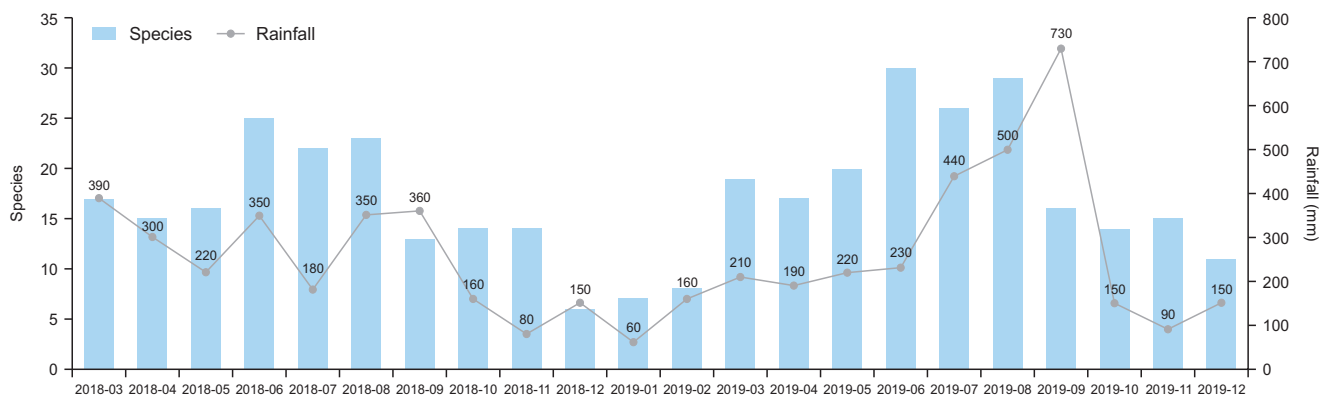**Fig. 4.** Comparison of temperature with number of species of birds for four seasons over two years.



**Fig. 5.** Comparison of precipitation with number of species of birds for four seasons over two years.

**Table 1.** Liner regression analysis data refereeing to temperature and precipitation

| Model | B | β | SE | t |
|---|---|---|---|---|
| Temperture | 0.740 | 0.787 | 0.000 | 4.30*** |
| Percipitation | −0.001 | −0.022 | 0.906 | −0.120 |
| (Constant) | 7.790 | - | 0.001 | 3.72 |

***$P<0.001$.

to conduct bird surveys on the trails (Bell, 1996; Deluca & King, 2014).

We have observed a higher number of Passeriformes in this study at the site for both surveyed years. The presence of a higher number of Passeriformes is related to the absence of aquatic birds (Moreno-Mateos et al., 2009; Rosselli & Stiles, 2012). The absence of diverse submerged plants, deep water depth and isolated geographical locations makes difficult for aquatic birds to prefer this area, and this has resulted in the dominance of Passeriformes (Pöysä et al., 2013).

The seasonally analyzed species diversity and evenness showed a relatively stable population of 2.40 to 2.90 and 0.82 to 0.90, respectively, but the richness showed seasonal variations of 3.63 in the winter to 5.70 in summer. In general, the species diversity, evenness, and richness are influenced by geographical, meteorological, physical, and biological factors (Mäkeläinen & Lehikoinen, 2021). Jeju Island is a geopolitical stopover site for migratory birds, especially in the middle of Mt. Hallasan Mountain, where summer visitor birds breed and spend their summer time (Kim et al., 2010; 2019). Human interference during the breeding season is limited since the area is restricted for visitors. Therefore, it is expected to have a higher species richness during the summer compared to any other seasons. However, studies on food resources, such as invertebrates and insects, have not yet been conducted, so it is hard to predict the relationship among the species richness and other biological factors. Furthermore, various factors need to be investigated that affect the bird populations.

To a large extent, the climatic preferences of the species determine their response to climate change (Nichelmann & Tzschentke, 2002). Temperature preferences play a key role in driving trends in animal populations (Gaüzère et al., 2016). However, the relative importance of the
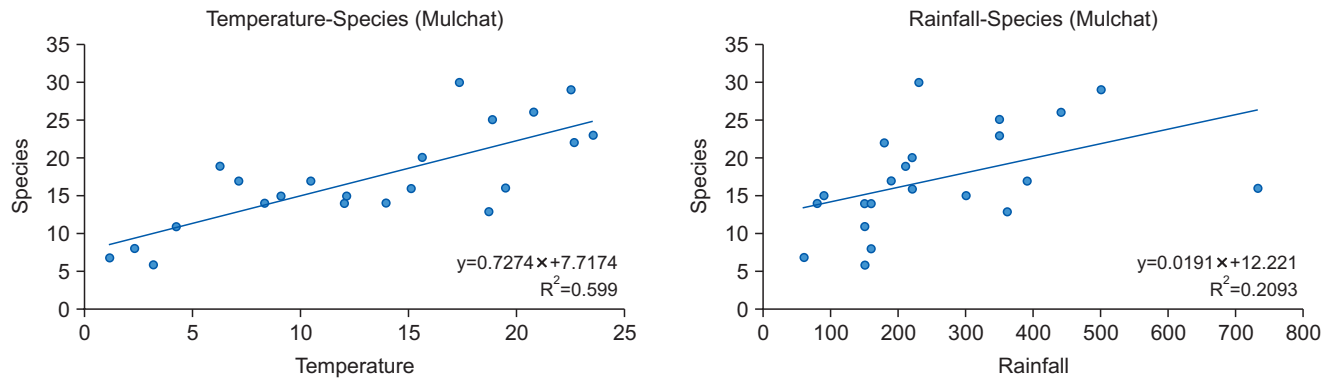
**Fig. 6.** The correlation between rainfall and temperature with number of species on Mulchat-oream.

temperature and precipitation preferences is still poorly understood, particularly in systems where ecological processes are strongly constrained by the amount and timing of rainfall (Knape & de Valpine, 2010). In this study, we have estimated the role played by the temperature and precipitation preferences in determining the population trends for birds in mountain wetlands. Trends were derived through biodiversity monitoring data and temperature and precipitation preferences were estimated from species appearance data. The results showed that the temperature trends were first and that precipitation is also related to the birds. A comparison of these shows that the precipitation preferences are less significant compared to temperature. Climatic factors, such as temperature and precipitation, may affect the bird communities directly via physiological constraints, for instance by restricting the activity, mobility and foraging time of the birds (Filloy *et al*., 2015).

The Korean Peninsula has historically offered a temperate climate (Lim *et al*., 2018), but it has recently been changing to a subtropical climate (Lee *et al*., 2017) due to global climate change (Wuebbles & Jain, 2001). These climatic factors create confusion upon migratory and native birds species that directly influences reproductive success. Climate change is causing mismatches in peak food availability, snow cover and other factors that could severely impact successful migration and reproduction of avian populations unless they are able to adjust to new conditions (Jetz *et al*., 2007). Resident birds also face challenges if precipitation and/or temperature patterns vary in ways that result in a mismatch for food and breeding (Rodenhouse *et al*., 2008).

Thus, this study shows the environmental factors and seasonal patterns that affect bird populations. It is believed that if long-term monitoring is carried out, the impact that temperature and precipitation have upon bird populations will be more clearly established.

## Conflict of Interest

## Acknowledgments

## References

Aleixo, A. (1999). Effects of selective logging on a bird community in the Brazilian atlantic forest. *The Condor*, 101, 537-548.

Baker, J., French, K., and Whelan, R. (2002). The edge effect and ecotonal species: Bird communities across a natural edge in southeastern Australia. *Ecology*, 83, 3048-3059.

Banjade, M., Han, S.H., Jeong, Y.H., Lee, J.W., and Oh, H.S. (2019). Long-term trends of bird community at Dongbaek-dongsan and 1100-Highland Wetland of Jeju Island, South Korea. *Korean Journal of Ornithology*, 26, 54-61.

Bell, J.F. (1996). Application of classification trees to the habitat preference of upland birds. *Journal of Applied Statistics*, 23, 349-360.

Brower, J.E., Zar, J.H., and von Ende, C.N. (1990). *Field and Laboratory Methods for General Ecology*. Dubuque: Wm. C. Brown.

Camp, R.J., and Knight, R.L. (1998). Rock climbing and cliff bird communities at Joshua Tree National Park, California. *Wildlife Society Bulletin*, 26, 892-898.

Cormont, A., Vos, C.C., van Turnhout, C.A.M., Foppen, R.P.B., and ter Braak, C.J.F. (2011). Using life-history traits to explain bird population responses to changing weather variability. *Climate Research*, 49, 59-71.

Covy, N., Benedict, L., and Keeley, W.H. (2019). Rock climbing activity and physical habitat attributes impact avian community diversity in cliff environments. *PloS One*, 14, e0209557.

Deluca, W.V., and King, D.I. (2014). Influence of hiking trails on montane birds. *The Journal of Wildlife Management*, 78, 494-502.

Filloy, J., Grosso, S., and Bellocq, M.I. (2015). Urbanization altered latitudinal patterns of bird diversity-environment relationships in the southern Neotropics. *Urban Ecosyst*, 18, 777-791.

Fisher, R.J., and Davis, S.K. (2010). From Wiens to Robel: a review of grassland-bird habitat selection. *The Journal of Wildlife Management*, 74, 265-273.

Frommolt, K.H., and Tauchert, K.H. (2014). Applying bioacoustic methods for long-term monitoring of a nocturnal wetland bird. *Ecological Informatics*, 21, 4-12.

Gaüzère, P., Jiguet, F., and Devictor, V. (2016). Can protected areas mitigate the impacts of climate change on bird's species and communities? *Diversity and Distributions*, 22, 625-637.

Grinde, A.R., Niemi, G.J., Sturtevant, B.R., Panci, H., Thogmartin, W., and Wolter, P. (2017). Importance of scale, land cover, and weather on the abundance of bird species in a managed forest. *Forest Ecology and Management*, 405, 295-308.

Hashimoto, K., Kasai, A., Hayasaka, D., Goka, K., and Hayashi, T.I. (2020). Long-term monitoring reveals among-year consistency in the ecological impacts of insecticides on animal communities in paddies. *Ecological Indicators*, 113, 106227.

Ismail, A., Rahman, F., and Zulkifli, S.Z. (2012). Status, composition and diversity of avifauna in the artificial Putrajaya wetlands and comparison with its two neighboring habitats. *Tropical Natural History*, 12, 137-145.

Jetz, W., Wilcove, D.S., and Dobson, A.P. (2007). Projected impacts of climate and land-use change on the global diversity of birds. *PLoS Biology*, 5, e157.

Kattan, G.H., and Franco, P. (2004). Bird diversity along elevational gradients in the Andes of Colombia: area and mass effects. *Global Ecology and Biogeography*, 13, 451-458.

Kim, E.M., Kang, C.W., Choi, C.Y., Chun, J.H., and Nam, H.Y. (2019). Vertical distribution and elevation preference for the breeding of fairy pittas on Jeju island, Korea. *Forests*, 10, 1010.

Kim, W.B. (2008). Avifauna of Mara Island, Korea. *Journal of Korean Nature*, 1, 143-148.

Kim, W.B., Jin, S.D., Yu, J.P., Paik, I.H., Kang, J.H., and Paek, W.K. (2014). Characteristics of the birds community in the islands off the West Coast of Seogwipo City, Korea. *Journal of Asia-Pacific Biodiversity*, 7, e156-e163.

Kim, Y.H., Oh, H.S., Jang, Y.C., and Choi, S.S. (2010). Nest environment selection of black paradise flycatcher (*Terpsiphone atrocaudata*). *Korean Journal of Ornithology*, 17, 11-19.

Knape, J., and de Valpine, P. (2011). Effects of weather and climate on the dynamics of animal population time series. *Proceedings Biological Sciences*, 278, 985-992.

Koh, J.G., and Kim, C.S. (2011). Distributional characteristics of woody plants in the evergreen broad-leaved forest in Dongbaekdongsan as a long term ecological research site. *Research Report on Hallasan*, 10, 41-54.

Laiolo, P., and Rolando, A. (2005). Forest bird diversity and ski-runs: a case of negative edge effect. *Animal Conservation*, 8, 9-16.

Lee, H., Kim, G., Park, C., and Cha, D.H. (2017). A study of future changes of climate classification and extreme temperature events over South Korea in multi regional climate model simulations. *Journal of Climate Research*, 12, 149-164.

Lee, W.S., Koo, T.H., and Park, J.Y. (2014). *A Field Guide to the Birds of Korea*. Seoul: LG Evergreen Foundation.

Lim, C.H., Yoo, S., Choi, Y., Jeon, S.W., Son, Y., and Lee, W.K. (2018). Assessing climate change impact on forest habitat suitability and diversity in the Korean peninsula. *Forests*, 9, 259.

Mäkeläinen, S., and Lehikoinen, A. (2021). Biodiversity and bird surveys in Finnish environmental impact assessments and follow-up monitoring. *Environmental Impact Assessment Review*, 87, 106532.

Margalef, R. (1994). Diversity and biodiversity - their possible meaning in relation with the wish for sustainable development. *Anais da Academia Brasileira de Ciências*, 66(Suppl 1), 3-14.

Martin, K., and Wiebe, K.L. (2004). Coping mechanisms of alpine and arctic breeding birds: extreme weather and limitations to reproductive resilience. *Integrative and Comparative Biology*, 44, 177-185.

Maxwell, S.L., Butt, N., Maron, M., McAlpine, C.A., Chapman, S., Ullmann, A., *et al*. (2019). Conservation implications of ecological responses to extreme weather and climate events. *Diversity and Distributions*, 25, 613-625.

Moreno-Mateos, D., Pedrocchi, C., and Comín, F.A. (2009). Avian communities' preferences in recently created agricultural wetlands in irrigated landscapes of semi-arid areas. *Biodiversity and Conservation*, 18, 811-828.

Nagelkerken, I., and Munday, P.L. (2016). Animal behaviour shapes the ecological effects of ocean acidification and warming: moving from individual to community-level responses. *Global Change Biology*, 22, 974-989.

National Institute of Biological Resources (NIBR). (2019). *National Species List of Korea*. Incheon: NIBR.

National Institute of Biological Resources (NIBR). (2020). *National Species List of Korea*. Incheon: NIBR.

Nichelmann, M., and Tzschentke, B. (2002). Ontogeny of thermoregulation in precocial birds. Comparative biochemistry and physiology. *Part A*, *Molecular & Integrative Physiology*, 131, 751-763.

Oh, H.S. (2002). Bird community in Mt. Halla National Park. *The Journal of Basic Sciences Cheju National University*, 15, 29-44.

Ornithological Society of Korea. (2009). *Checklist of the Birds of Korea*. Seoul: Hanrimwon.

Park, C.R., Kim, E.M., Kang, C.W. (2011). The characteristics of bird community at Hannam area of Jeju experimental forests. *Korean Journal of Environment and Ecology*, 25, 828-835.

Park, H.S. (1990). A study of birds in seven uninhabited islands along the coast of Jeju island. In Jeju MBC. (Ed.), *Uninhabited Islands Research Report on Jeju Island* (pp. 83-110). Jeju: Jeju MBC.

Pöysä, H., Rintala, J., Lehikoinen, A., and Väisänen, R.A. (2013). The importance of hunting pressure, habitat preference and life history for population trends of breeding waterbirds in Finland. *European Journal of Wildlife Research*, 59, 245-256.

Rathod, J., Lakhmapurkar, J., Gavali, D., Patel, T., Singh, N., and Patel, I. (2016). Avifaunal diversity at two ponds of Waghodiya taluka of Vadodara District, India. *International Research Journal of Environmental Sciences*, 5, 63-70.

Rodenhouse, N.L., Matthews, S.N., McFarland, K.P., Lambert, J.D., Iverson, L.R., Prasad, A., *et al*. (2008). Potential effects

of climate change on birds of the Northeast. *Mitigation and Adaptation Strategies for Global Change*, 13, 517-540.

Rosselli, L., and Stiles, F.G. (2012). Local and landscape environmental factors are important for the conservation of endangered wetland birds in a high Andean plateau. *Waterbirds*, 35, 453-469.

Salewski, V., Hochachka, W.M., and Fiedler, W. (2013). Multiple weather factors affect apparent survival of European passerine birds. *PloS One*, 8, e59110.

Seok, S.J., Park, I.C., Kim, Y.S., and Kim, W.G. (2010). Notes on rare species of mycoparasitic forming fungus in Korea. *The Korean Journal of Mycology*, 38, 95-98.

Shannon, C.E., and Weaver, W. (1949). *The Mathematical Theory of Communication*. Urbana (IL): University of Illinois Press.

Sharma, D., Vishwakarma, A., and Yadav, K.C. (2014). The Water Birds of Gidhwa & Parsada Wetlands, Nandghat, Bemetara, Chhattisgarh (India). *International Journal of Scientific and Research Publications*, 4, 1-8.

Stephens, D.W. (1991). Change, regularity, and value in the evolution of animal learning. *Behavioral Ecology*, 2, 77-89.

Thiollay, J.M. (1997). Disturbance, selective logging and bird diversity: a Neotropical forest study. *Biodiversity and Conservation*, 6, 1155-1173.

Thiollay, J.M. (1999). Responses of an avian community to rain forest degradation. *Biodiversity and Conservation*, 8, 513-534.

VanRees-Siewert, K.L., and Dinsmore, J.J. (1996). Influence of wetland age on bird use of restored wetlands in Iowa. *Wetlands*, 16, 577-582.

Whited, D., Galatowitsch, S., Tester, J.R., Schik, K., Lehtinen, R., and Husveth, J. (2000). The importance of local and regional factors in predicting effective conservation: planning strategies for wetland bird communities in agricultural and urban landscapes. *Landscape and Urban Planning*, 49, 49-65.

Wuebbles, D.J., and Jain, A.K. (2001). Concerns about climate change and the role of fossil fuel use. *Fuel Processing Technology*, 71, 99-119.

Yuan, Y., Zeng, G., Liang, J., Li, X., Li, Z., Zhang, C., *et al.* (2014). Effects of landscape structure, habitat and human disturbance on birds: a case study in East Dongting Lake wetland. *Ecological Engineering*, 67, 67-75.

**Supplementary Table 1.** Number of birds recorded on Mulchat-oream study sites in Halla mountain

| No. | Scientific name | 2018 Ind (ea) | 2018 Dom (%) | 2019 Ind (ea) | 2019 Dom (%) | Total Ind (ea) | Total Dom (%) | Mig |
|---|---|---|---|---|---|---|---|---|
| | **Columbidae** | | | | | | | |
| 1 | *Streptopelia orientalis* | 11 | 5.2 | 11 | 4.5 | 11 | 4.3 | Res. |
| | Cuculidae | | | | | | | |
| 2 | *Cuculus poliocephalus* | 4 | 1.9 | 2 | 0.8 | 4 | 1.6 | S.V. |
| 3 | *Cuculus saturatus* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | S.V. |
| | **Accipitridae** | | | | | | | |
| 4 | *Accipiter nisus* | 1 | 0.5 | 1 | 0.4 | 1 | 0.4 | W.V. |
| 5 | *Accipiter soloensis* | 1 | 0.5 | 2 | 0.8 | 2 | 0.8 | S.V. |
| | **Falconidae** | | | | | | | |
| 6 | *Falco peregrinus* | 1 | 0.5 | 1 | 0.4 | 1 | 0.4 | Res. |
| | **Aegithalidae** | | | | | | | |
| 7 | *Aegithalos caudatus* | 6 | 2.8 | 5 | 2.1 | 6 | 2.4 | Res. |
| | **Corvidae** | | | | | | | |
| 8 | *Corvus corone* | 1 | 0.5 | 3 | 1.2 | 3 | 1.2 | Res. |
| 9 | *Corvus macrorhynchos* | 8 | 3.8 | 9 | 3.7 | 9 | 3.5 | Res. |
| 10 | *Garrulus glandarius* | 3 | 1.4 | 5 | 2.1 | 5 | 2.0 | Res. |
| 11 | *Pica pica* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | Res. |
| | **Emberizidae** | | | | | | | |
| 12 | *Emberiza elegans* | 14 | 6.6 | 19 | 7.9 | 19 | 7.5 | Res. |
| 13 | *Emberiza rustica* | 7 | 3.3 | 3 | 1.2 | 7 | 2.7 | W.V. |
| | **Fringillidae** | | | | | | | |
| 14 | *Carduelis sinica* | 23 | 109 | 39 | 161 | 39 | 153 | Res. |
| | **Hirundinidae** | | | | | | | |
| 15 | *Hirundo rustica* | 14 | 6.6 | 14 | 5.8 | 14 | 5.5 | S.V. |
| | Monarchidae | | | | | | | |
| 16 | *Terpsiphone atrocaudata* | 4 | 1.9 | 4 | 1.7 | 4 | 1.6 | S.V. |
| | **Motacillidae** | | | | | | | |
| 17 | *Motacilla alba* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | P.M. |
| 18 | *Motacilla cinerea* | 3 | 1.4 | 4 | 1.7 | 4 | 1.6 | Res. |
| | **Muscicapidae** | | | | | | | |

| No. | Species | Ind | Dom | Ind | Dom | Ind | Dom | Mig |
|---|---|---|---|---|---|---|---|---|
| 19 | *Cyanoptila cyanomelana* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | S.V. |
| 20 | *Ficedula zanthopygia* | 2 | 0.9 | 2 | 0.8 | 3 | 1.2 | S.V. |
| 21 | *Luscinia cyane* | 2 | 0.9 | 3 | 1.2 | 3 | 1.2 | P.M. |
| 22 | *Muscicapa dauurica* | | | 2 | 0.8 | 2 | 0.8 | P.M. |
| 23 | *Muscicapa griseisticta* | 3 | 1.4 | 3 | 1.2 | 3 | 1.2 | P.M. |
| | **Paridae** | | | | | | | |
| 24 | *Parus ater* | 2 | 0.9 | 1 | 0.4 | 2 | 0.8 | Res. |
| 25 | *Parus major* | 12 | 5.7 | 13 | 5.4 | 13 | 5.1 | Res. |
| 26 | *Parus varius* | 9 | 4.3 | 10 | 4.1 | 10 | 3.9 | Res. |
| | **Pittidae** | | | | | | | |
| 27 | *Pitta nympha* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | S.V. |
| | Pycnonotidae | | | | | | | |
| 28 | *Microscelis amaurotis* | 13 | 6.2 | 15 | 6.2 | 15 | 5.9 | Res. |
| | **sylviidae** | | | | | | | |
| 29 | *Cettia diphone* | 7 | 3.3 | 8 | 3.3 | 8 | 3.1 | Res. |
| 30 | *Phylloscopus coronatus* | 4 | 1.9 | 2 | 0.8 | 4 | 1.6 | P.M. |
| 31 | *Phylloscopus inornatus* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | P.M. |
| | **Troglodytidae** | | | | | | | |
| 32 | *Troglodytes troglodytes* | 3 | 1.4 | 3 | 1.2 | 3 | 1.2 | Res. |
| | **Turdidae** | | | | | | | |
| 33 | *Turdus hortulorum* | 2 | 0.9 | 2 | 0.8 | 2 | 0.8 | S.V. |
| 34 | *Turdus pallidus* | 4 | 1.9 | 4 | 1.7 | 4 | 1.6 | S.V. |
| 35 | *Zoothera aurea* | 2 | 0.9 | 1 | 0.4 | 2 | 0.8 | S.V. |
| | Zosteropidae | | | | | | | |
| 36 | *Zosterops japonicus* | 30 | 14.2 | 37 | 15.3 | 37 | 14.5 | Res. |
| | **Picidae** | | | | | | | |
| 37 | *Dendrocopos leucotos* | 3 | 1.4 | 2 | 0.8 | 3 | 1.2 | Res. |
| | **Number of species** | **36** | | **37** | | **37** | | |
| | **Number of individual** | **211** | | **242** | | **255** | | |
| | **Species diversity** | **3.14** | | **3.02** | | **3.09** | | |
| | **Species evenness** | **0.88** | | **0.84** | | **0.86** | | |
| | **Species richness** | **6.54** | | **6.56** | | **6.50** | | |

Ind, individual; Dom, dominance; Mig, migratory type; ea, each; Res., resident; S.V., summer vagrant; W.V., winter vagrant; P.M., passage migrant.