The Conservation and Population Dynamics of Falconiformes and Strigiformes at North Coast of Taiwan

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I. Research Background

The main island of Taiwan is located in the center of the Festoon Islands chain on the west coast of the Pacific Ocean. It is located on the migratory path of East Asian migratory birds. In addition, it has a variety of suitable habitats for different migratory birds to live in. It can also be a stopover site or destination for migratory birds. There are coastal updrafts and the windward side of the northeast monsoon on the North Coast, located at the extreme northern tip of Taiwan. During the spring and autumn migration seasons, there are a large number of migratory raptors passing through, including Goshawk and other resident raptors. In recent years, the peregrine falcon, originally a winter migratory bird and transit bird, has several breeding records on the north coast, making the north coast a hot spot for raptors. Birds of prey are important predators and high-level consumers in Taiwan's forest ecosystem. They are keystone species at the top of the food web and play a role in stabilizing the ecosystem. Based on the spirit of deep cultivation and ecological conservation, Hsieh-ho Power Plant plans to research raptor conservation in line with local ecological characteristics so that ecological conservation and environmental declarations are by no means mere slogans.

Active actions demonstrate the determination and ability of ecological conservation and resolve economic development and conflicts. In addition to developing the electric industry to promote the economy, it must not be absent in ecological conservation to achieve an ecological power plant.

In response to the national energy policy, Taipower has been successively planning for energy transformation and projects to gradually displace coal-fired and oil-fired units with gas-fired units. In addition, public ecological awareness has been increasing in recent years, and the ecological pressure has also increased when we conducted the environmental assessments for renewal and reconstruction projects.

Ecological issues have gradually replaced air pollution, Noise, water discharge, etc., and have become key issues in the EIA. Taipower's environmental white paper also marks "creating ecological harmony" as one of the six major strategic aspects, and all power development plans are moving towards ecological power plants; the raptors on the north coast are important local ecological features, and the black kite is the city bird of Keelung City. The conservation of raptors is a very suitable issue for Hsieh-ho Power Plant. In addition to responding to conservation expectations with practical actions, it also expresses the determination of the power plant never to be absent in ecological conservation.

II. Research Content

The content of this research case explores the relationship between the distribution of black kites and peregrine falcons and environmental factors, finds out the habitat selection factors of black kites and peregrine falcons, predicts the distribution of habitat fitness, finds out potential conservation areas, and intervenes conservation as a way to achieve the goal of scientific conservation.

Conservation planning and effective management often depend on the understanding of species habitat use characteristics and distribution (Pearce and Boyce, 2006). Habitat refers to the physical space that a species lives in. The species selects and utilizes the biotic and abiotic resources of the space and can tolerate extreme climatic conditions and threats from competitors and predators in this space. Therefore, it can survive safely in it (Morrison et al., 2006).

In recent years, with the advancement of computer hardware, the development of geographic information systems (geographic information system, GIS), and remote sensing technology (remote sensing technique), researchers have improved the efficiency of habitat use and distribution study. They can propose more clear Habitat management suggestions, and the feedback from conservationists has become a policy for researchers to modify and strengthen. The combination and application of fields can benefit both sides (Stauffer, 2002).

This study covers the entire island of Taiwan. The main research purposes are as follows:

(1) Collect open data on the distribution points of black kites and peregrine falcons.

(2) Collect environmental factor data.

(3) Understand the preference of black kite and peregrine habitat use.

(4) Understand the differences in habitat use between the black kite and the peregrine falcon.

(5) Establish habitat fitness distribution maps for black kites and peregrine falcons to understand the distribution of large raptor habitats in Taiwan.

(6) Understand the protection effect of the current conservation areas and conservation policies along the North Coast on the habitats of black kites and peregrine falcons.

III. Research Results

3.1 Distribution points of black kites and peregrine falcons

The distribution points of the black kite and the peregrine falcon were obtained from the Taiwan Biodiversity Network (Taiwan Biodiversity Network) using the Taiwan Wild Bird Federation Bird Records Database.

There are 5,663 recorded points for black kites and 3,931 recorded points for peregrine falcons. The points of black kites and peregrines are shown in Figure 1 and Figure 2.

3.2 Environmental Factors

There are 100 environmental factors in the multi-time series data set of Taiwan land area environmental factors, and all environmental factors are listed in Table 1.

This study refers to several related literature on raptor or wild animal habitat simulation (Wu Yinren, 2007; Hong Yujun, 2009; Lu Minglun, Huang Jingyi, 2017), and finally selected 12 environmental factor indicators through the comparison of various literature, and using Chen Wanjun et al. (2020) multi-time-series data set of Taiwan land area environmental factors to extract basic data features, the meanings of each environment are described as follows.

(1) Average daily temperature (Temp, °C): the average daily average temperature of each month from January to December and the monthly average temperature of the 12 months in total.

(2) Average daily solar radiation (ASR, MJ/m2): Area Solar Radiation (ASR), meaning the average annual sunshine.

(3) Average monthly total rainfall (Prec, mm): same as Monthly precipitation sums, which means the average monthly precipitation from January to December.

(4) Mean Elevation (ELE, m): the average altitude in the grid.

(5) Elevation standard deviation (ELERA, m): The Elevation Range (ELERA), which is also the span of altitude, is the difference between ELEMAX and ELEMIN. This value indicates the degree of ruggedness in the grid; the larger the value Indicates that the terrain in this area is more rugged.

(6) Average slope (Slope, °): The average altitude value of the grid, the higher the value, the steeper it is.

(7) Terrain index (ELESD, m): It is also the Standard Deviation of Elevation (ELESD), which means the degree of altitude variation. A positive value is a more convex terrain, such as a mountain top or a ridgeline; a value close to 0 means a flat surface Terrain, such as slopes or flats. Negative values indicate concave terrain, such as valleys or basins.

(8) The shortest distance to freshwater body (DFW, km): the same as the shortest distance to fresh water body (Nearest Distance to Fresh Water, DFW), calculate the distance between each grid center point and freshwater body, and the data source of fresh water body is the traffic road network value The layer of rivers and lakes provided by the map.

(9) Forest coverage (FO, m2): Broad-leaved forest, coniferous forest, part of farmland and natural vegetation mosaic (trees, shrubs, herbs), part of natural vegetation mosaic (trees, shrubs, and herbs), part of sparse vegetation (trees, shrubs, herbaceous plants) and land cover types such as

waterside and coastal forests

(10) Nature index

(11) Calculation of NDVI value: Normalized Difference Vegetation Index (NDVI) The principle is that chlorophyll (Chlorophyll) in plants has a large amount of absorption for red light (R) and strong reflection of near-infrared light (NIR). It is calculated as (NIR - Red)/(NIR + Red). When there is more chlorophyll, and the vegetation density is higher, the reflected near-infrared light value will be higher, and NDVI will be close to 1, so the near-infrared light value is the health status of the leaves index. The NDVI for soil and rock will yield values close to 0 since both have similar values in red and near-infrared light. Water is more reflective of red light than near-infrared light so that NDVI will be closer to -1. The layer data used in this research image is taken from the website of the United States Geological Survey (USGS). After the image spectrum is stacked and corrected, the projected coordinates are converted, and the NDVI value can be calculated.

(12) Road density (LRoad, m):

The same is the road length (Road Length, LROAD), which means that the primary source of road data is the numerical map of the traffic road network. Existing roads, such as industrial roads and roads without road names, are combined with 81 forest road maps (to form a complete road network map, and then the length of roads in each 1 km2 grid is calculated.

To reduce the multicollinearity caused by the high correlation between the above 12 environmental factors, the Spearman's correlation test was performed on each environmental factor using the statistical software SPSS 12.0, and one of the two environmental factors with a correlation coefficient greater than 0.8 was removed.

3.3 Relationship between distribution points of black kite and peregrine falcon and environmental factors

The Spearman’s correlation coefficients were calculated to avoid the multicollinearity issue, which would affect the data interpretation of subsequent statistical analysis. The twelve environmental factors were compared in pairs, and one was deleted when the absolute value of the correlation coefficient was greater than 0.8, leaving a total of eight environmental factors. The Spearman’s correlation matrix is shown in Table 2.

The five variables of forest (FO), average daily temperature (Temp), average elevation (ELE), elevation span (ELERA), slope (Slope), and elevation change (ELESD) showed significant multicollinearity among each other. Therefore, four variables (environmental factors) including forest (FO), average daily temperature (Temp), average altitude (ELE), altitude span (ELERA), and slope (Slope) were deleted in this study, leaving eight environmental factors for subsequent statistical analysis.

3.4 Habitat fitness distribution prediction of black kite and peregrine falcon in Taipei and New Taipei City and Keelung, and the coverage effect of existing protected areas

Taiwan's coastal areas are rich in natural resources. Given the rapid disappearance of coastal resources, the Construction Administration of the Ministry of the Interior invited relevant departments, experts, and scholars to carry out two "Natural Environmental Protection Plans for Taiwan's Coastal Areas" in 1970 and 1974. Until 1976, the administration The court announced the designation of twelve coastal protected areas, which were subdivided into general protected areas and nature protected areas according to their resource characteristics. Nature reserves prohibit any behavior that changes the existing ecological features and natural landscapes and strengthen the protection of natural resources in the area; while the protection policy of general reserves is to maintain the current resource utilization without affecting the environmental ecological features and natural landscapes type.

The Hsieh-ho Power Plant is adjacent to the North Coast Coastal Reserve. The location of the general reserve, nature reserve, and the potential habitat predictions for black kites and peregrine falcons are shown in Figures 3 to 4. Taking habitat suitability at 0.5 as the cut-off point, it is a conservative expansion protection strategy. When the conservation funds are abundant or the population is at high risk of extinction, the scope of protection can be started.

Take the existing North Coast Coastal Reserve for example, with the 0.5 dichotomy method, there are 10.84% of the potential habitats of black kites and 15.86% of the potential habitats of peregrine falcons However, there are still 89.16% (black kites) and 84.14% (peregrines) potential habitats that cannot be protected by government conservation policies, as shown in Table 3.

IV. Conclusion

This study is a rare ecological conservation scientific research completed in recent years using open data as the data source, combined with geographic information systems and statistical analysis techniques.

Ecological monitoring, which comes from environmental impact assessments, has always been a regular business of the company. However, the data itself does not produce scientific and conservation value. Only purposeful analysis and application have substantive significance. Otherwise, it is just administrative work to meet the requirements of environmental impact assessment procedures. Taiwan has many sources of ecological open data. Currently, there are the Taiwan Biodiversity Network of the Special Biological Research and Conservation Center of the Council of Agriculture, the Taiwan Biodiversity Information Institute (TaiBif) of the Academia Sinica, and the Global Biodiversity Information Institute (GBif). According to individual studies' content and attributes, suitable public data can be selected and utilized with scientific technology to produce research results with scientific value.

This research uses the survey data of black kite and peregrine falcon from the Taiwan Wild Bird Federation Bird Records Database. There are 5,663 records of black kites and 3,931 records of peregrine falcons, providing a large sample size for statistical analysis. Based on the solid foundation of statistical analysis, this study integrates and applies multiple time-series data sets of environmental factors in Taiwan's land area. After referring to many reference literature to deepen the understanding of the ecological habits of black kites and peregrine falcons, suitable environmental factors were selected. In addition, two databases, the naturalness index and NDVI analyzed and calculated by this research, were included in this study. The habitat selection factors, distribution predictions, and potential habitats of black kites and peregrine falcons in the main island of Taiwan are not only the basis for the raptor conservation work of Hsieh-ho Power Plant but also an essential reference for Taiwan and international conservation science.

The study shows that the habitat selection factors for black kites include high sunlight exposure, high rainfall amount, relatively flat terrain, low naturalness (urban or high land use), low vegetation index value, high urbanization level (road density), and location near water bodies. Peregrine falcons prefer areas with high sunlight exposure, relatively flat terrain, low naturalness value, low vegetation index value,and higher urbanization levels. There is no significant difference in their preference for water bodies.

The habitat selection factors of the black kite and the peregrine falcon are highly similar, and they both prefer locations with a large amount of sunshine, relatively gentle terrain, and high urbanization (naturalness, road density, and NDVI). However, black kites prefer areas with more rainfall amount and closer to water bodies compared to peregrine falcons. Therefore, the two species are very suitable as co-conservation species, and it is easy to consider the habitat requirements of the two species when formulating protection areas or conservation policies.

The habitat suitability analysis and coverage of the protected areas indicate that the eastern part of Taiwan, including Hualien County's Xincheng Township, Shoufeng Township, Jian Township, Fenglin Township to Guangfu Township, and the coast of Hualien County to Changbin Township and Yuli Township in Taitung County. These areas are locations with high habitat suitability for the black kite, which can be included in the protected area; and the analysis results of the habitat suitability of the peregrine falcon show that in addition to the north coast and Yilan as potential habitats, only the coastal areas from the Chianan Plain to Kaohsiung City are potential habitats. Therefore, a more lenient approach should be taken when setting up protected areas for peregrine falcons based on the 0.5 dichotomy method.

Regardless of whether using the 0.5 dichotomy or 0.7 dichotomy method for predicting Maxent habitat fitness distribution, the Hsieh-ho Power Plant site and its surroundings are potential habitats for black kites and peregrine falcons. Consequently, satisfactory protection and conservation effects can be achieved through habitat adoption within or around the site.

表 一、臺灣陸域環境因子多時序資料集環境因子項目總表

9 個土地覆蓋因子									
縮寫	FF	MD	FW	FO	WL	UB	WB	BU	BL
中文	農田(m²)	草本(m²)	農濕地(湛水)(m²)	森林(m²)	濕地(m²)	都市(m²)	水體(m²)	灌叢(m²)	裸露地(m²)
8 個地形因子(DTM)									
縮寫	ELE	ELEMAX	ELEMIN	ELERA	ELESD	Slope	Aspect	ASR	
中文	平均海拔(m)	最高海拔(m)	最低海拔(m)	海拔跨幅(m)	海拔變化(m)	坡度(degree)	坡向(degree)	日射量	
4 個其他因子(other)									
縮寫	LROAD			PROAD			DFW		
中文	道路長度(m)			道路有無(0 或 1)			最短淡水體距離(m)		
79 個氣候因子(climate)									
縮寫	Temp(月份)	Tmax(月份)	Tmin(月份)	Tra(月份)	Prec(月份)	Bio01	Bio02	Bio03	Bio04
中文	月均溫(℃)	月高溫(℃)	月低溫(℃)	每月平均日溫差(℃)	月降雨量(mm)	年均溫(℃)	平均日溫差(℃)	溫度恆定性(%)	溫度季節性(℃)
縮寫	Bio05	Bio06	Bio07	Bio08	Bio09	Bio10	Bio11	Bio12	Bio13
中文	最暖月份之最高溫(℃)	最冷月份之最低溫(℃)	年溫差(℃)	最潮濕季節之平均溫度(℃)	最乾燥季節之平均溫度(℃)	最溫暖季節之平均溫度(℃)	最寒冷季節之平均溫度(℃)	年降雨量(mm)	最潮濕月份之降水量(mm)
縮寫	Bio14	Bio15	Bio16	Bio17	Bio18	Bio19			
中文	最乾燥月份之降水量(mm)	降水之季節性(%)	最潮濕季節之降水量(mm)	最乾燥季節之降水量(mm)	最溫暖季節之降水量(mm)	最寒冷季節之降水量(mm)			

表 二 、環境因子間的相關性；Spearman' s correlation 相關係數矩陣

	Temp	ASR	Prec	ELE	ELERA	Slope	ELESD	DFW	FO	natrue ind	NDVI	LROAD
Temp	1.000											
ASR	-.387**	1.000										
Prec	-.674**	.268**	1.000									
ELE	-.928**	.463**	.672**	1.000								
ELERA	-.839**	.263**	.674**	.916**	1.000							
Slope	-.842**	.251**	.660**	.919**	.976**	1.000						
ELESD	-.830**	.250**	.671**	.907**	.993**	.973**	1.000					
DFW	-.153**	.314**	.171**	.229**	.213**	.202**	.211**	1.000				
FO	-.800**	.239**	.671**	.870**	.869**	.878**	.864**	.153**	1.000			
natrue ind	-.704**	.248**	.600**	.776**	.782**	.793**	.778**	.149**	.789**	1.000		
NDVI	-.541**	.212**	.504**	.641**	.665**	.660**	.665**	.128**	.697**	.705**	1.000	
LROAD	.428**	.132**	-.267**	-.362**	-.369**	-.376**	-.368**	.187**	-.448**	-.409**	-.228**	1.000

註 1：相關係數絕對值大於 0.8 者以粗體標示；各環境因子縮寫與中文名參照請見表一。

註 2：**：p<.01

表 三 、黑鳶及遊隼預測棲地受保護區涵蓋比例(0.5 二分法)

	沿海一般保護區		沿海自然保護區			未受保護區域	總面積/比例
	淡水河口	北海岸沿海	淡水河口	北海岸沿海	東北角沿海		
黑鳶(ha)	2, 247. 38	9, 359. 55	186. 33	123. 46	7, 147. 51	138, 299. 89	155, 116. 74
黑鳶(%)	1. 45	6. 03	0. 12	0. 08	4. 61	89. 16	100. 00
遊隼(ha)	2, 247. 38	9, 359. 55	186. 33	123. 46	7, 147. 51	89, 194. 90	106, 011. 75
遊隼 (%)	2. 12	8. 83	0. 18	0. 12	6. 74	84. 14	100. 00

Tables 1 to 3 are tabulated for this study

Figure 1. Distribution of black kites (drawn in this study)

Figure 2. Distribution of peregrine falcons (drawn in this study)

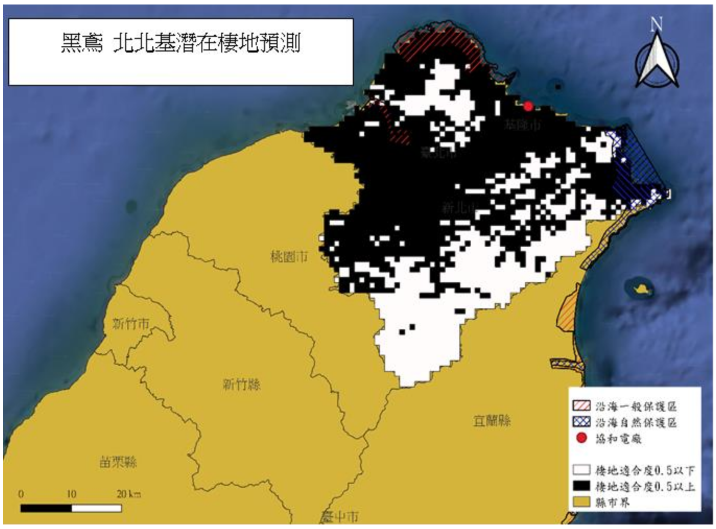

Figure 3. Predicted habitats and current protected areas of black kites in Beibeiji (0.5 dichotomy) (drawn in this study)

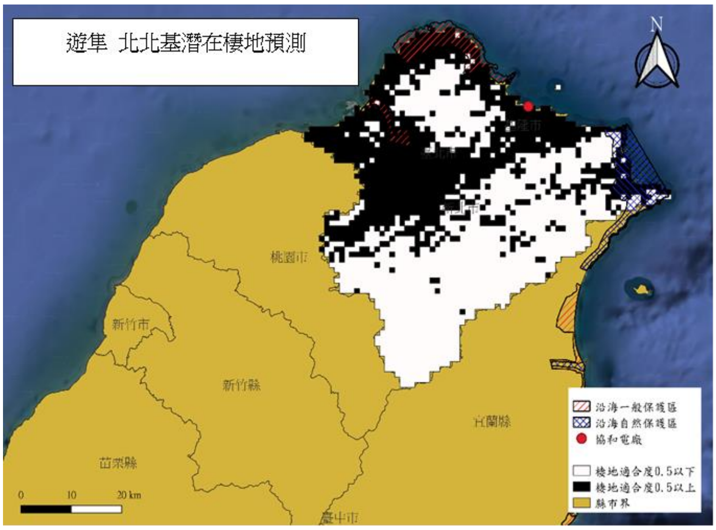

Figure 4. Predicted habitats and current protected areas of peregrine falcons in Beibeiji (0.5 dichotomy) (drawn in this study)