Pakistan J. Zool., vol. 53(2), pp 635-641, 2021 DOI: https://dx.doi.org/10.17582/journal.pjz/20191130101121

Foraging and Day-roosting Sites Selection by the Endangered Brown-eared Pheasant *Crossoptilon mantchuricum* during Autumn in the Huanglong Mountains, Shaanxi Province, China

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Article Information
Received 30 November 2019
Revised 18 March 2020
Accepted 06 April 2020
Available online 22 February 2021

Authors' Contribution
HL, XL, ZH, SW and CC conceived the study. HL executed the study. HL and XL analyzed the data and wrote the manuscript.

Key words
Brown-eared pheasant (*Crossoptilon mantchuricum*), Foraging sites, Day-roosting sites, Stepwise discriminant analysis

ABSTRACT

Understanding animal habitat selection is significant for informed conservation management actions. The autumn foraging and day-roosting site selection of the brown-eared pheasant (*Crossoptilon mantchuricum*) was studied in Huanglong Mountains Nature Reserve, Shaanxi Province, China from October to November 2018. Data were collected by examination of fresh sites used by the brown-eared pheasant located on 22 transects across the entire study area. The results showed that foraging habitats were characterized by broadleaved forest, mid and upper slope location, and gully while day-roosting habitats by ridge, upper slope location, and sunny slope. The foraging sites utilized by the birds also featured higher altitude, steeper slope, bigger tree heights and diameter, smaller shrub cover and lower herb height, and higher sheltering class. The overall classification model developed from these seven variables helped distinguish foraging sites from random ones at probability of 90.2%; while day-roosting sites tended to be found in the areas of higher altitude, smaller tree cover, lower shrub cover and height, lower herb height and sheltering class, far away from households, and close to woodside and the overall classification model developed from these five variables was successful in distinguishing day-roosting sites from random ones at probability of 88.90%. Besides, water source is not one of the key factors affecting wildlife habitat selection in this season. Management of the brown-eared pheasant populations for conservation must account for the daily activity rhythm shifts in habitat requirements.

INTRODUCTION

Habitat is a place of life activity occupied by wildlife at a certain stage of its life cycle (Powell *et al*., 1996). It can provide sufficient food resources, water resources and concealed places to ensure survival and reproduction (Zhang and Zheng, 1999; Zhao *et al*., 2012; Yan *et al*., 2016). Habitat quality directly affects the geographical distribution, population density and reproductive success rate of animals (Cody, 1985; Milan *et al*., 2018). Animal habitat selection comes from the results of the simultaneous consideration of many factors, including the need for foraging and concealment to avoid extreme weather and predators (Ratikainen *et al*., 2007). Habitat selection is the outcome of trade-offs between the costs and benefits (Sih, 1980; Lima and Dill, 1990; Ratikainen *et al*., 2007). Therefore, understanding animal habitat preferences provides fundamental ecological information that is vital for effective management (Alves *et al*., 2017). Foraging site is an important place for wildlife to obtain food and its quality is directly related to the survival and reproduction of animals. Bedding habitat is a resting place for wildlife, where it is not only easy to avoid the capture by natural enemies, but also able to withstand the bad weather. As far as birds are concerned, day-roosting, called "dust bathing" by some scholars, is generally shown as rolling back and forth in the sand, sticking sand on feathers, and shaking off and as a result, it often combs feathers, expels parasites, enhances skin health and digestive function of birds (Charles *et al*., 1993; Lu *et al*., 2002). Therefore, foraging and day-roosting sites are the most important environmental events in wildlife history. Furthermore, habitat selection for wildlife is the trade-offs between the costs and benefits connected with each habitat (Lima and Dill, 1990). The knowledge about the selection of foraging and day-roosting sites by wild birds will help understand the differences between foraging and day-roosting sites, further reveal the mechanism of these differences, and provide a basis for wildlife protection.

The brown-eared pheasant (*Crossoptilon mantchuricum*),

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0030-9923/2021/0002-0635 $ 9.00/0

a species endemic to China, is classified as a Category I Protected Wild Animal Species under the Wild Animal Protection Law in China, listed as "Endangered" in the China Red Data Book of Endangered Animals and is "vulnerable" by International Union for the Conservation of Nature (IUCN) because of its restricted range (<13,000 km^2), small population (<17,900 birds), and severely fragmented habitat (IUCN, 2017). Owing to the geographical barriers (the Yellow River) and forest loss, the species exists as three isolated geographical populations: the middle population in Shanxi; the eastern population in Hebei and Beijing; and the western population in Shaanxi including Yanan and Hancheng City (Wu *et al*., 2015). The brown-eared pheasant is regarded as habitat specialist because it is sedentary with limited dispersal (Johnsgard, 1999; Zhang *et al*., 2003; Xu *et al*., 2010). As a result, the brown-eared pheasant is confronted with great pressure of survival from their natural predators (Houtman and Dill, 1998). The specific habitat selection of this species is significant for conservation efforts and habitat management (Zhang *et al*., 2010; Alves *et al*., 2017). Based on the previous studies, the daily activity rhythm of this pheasant is usually morning and afternoon foraging and noon day-roosting (Liu *et al*., 1991). Autumn is the busiest season including grain and medicinal plants collection for farmers, which inevitably affects the activities of this pheasant. However, the information on its autumn behavior remains unknown. The purpose of our study was to investigate the habitat preferences of the pheasant during autumn in Huanglong Mountains, Shaanxi Province, China. Our results can be used to develop a conversation and management strategy for the pheasant in China.

MATERIALS AND METHODS

Study site

The study was carried out in Daling and Getai protection station of the Huanglongshan Nature Reserve (35°28′-36°02′N latitude, 109°38′-110°12′E longitude). The reserve is located in the forested area of Huanglong Mountains in the northeast of Shaanxi Province, China. The study area encompasses 81,753 ha with a central core area of 21,289 ha for wildlife conservation (especially for brown-eared pheasants) over an altitudinal range of 962.6 to 1783.5 m above mean sea level. The climate is sub-humid temperate continental. The mean annual average temperature is 8.6°C and the mean annual precipitation is 611.8 mm mainly concentrated from July to September. Vegetation in the study area is mainly warm temperate deciduous broad leaved forest and percentage of forest cover amounts to 84.6%. Four major plant communities occur in this Reserve: 1) (Fig. 1) subtropical evergreen coniferous forest; 2) coniferous broadleaved forest; 3) deciduous broad-leaved forest and 4).

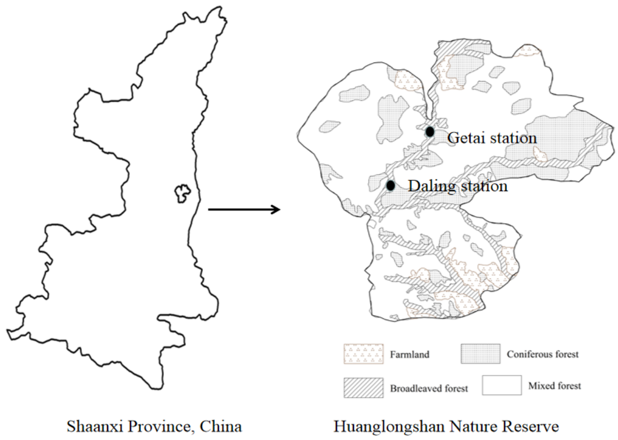

Fig. 1. Location and vegetation of Huanglongshan Nature Reserve (Yanan City, Shaanxi Province, China) and the position of protection stations used in the study area.

Data collection

Field data were collected during the autumn season from October to November in 2018. Twenty-two non-overlapping line transects, ranging from 2-4km (8 of Daling protection station and 14 of Getai protection station) laid the way from the bottom to the ridge covering all habitat types in the study region. Foraging signs of brown-eared pheasant, which can be recognized as overturned litter by the birds' strong beak and claws, are easy to distinguish from foraging signs of the common (ring-necked) pheasant (*Phasianus colchicus,* the only other sympatric Galliformes species), which feeds more selectively on insects and seeds in the taller grass, and its scratches are less obvious than those of brown-eared pheasants (Li *et al*., 2008) . Day-roosting sites of the brown-eared pheasant were identified based on molted feathers at each site. In addition, in order to reduce the underestimation of the presence of this species, each line transect was surveyed more than two times during the survey period.

We walked along transects at a speed of 1.5-2.0 km/h and searched for any sign of foraging or day-roosting within 25 meters of the transect. When one sign of foraging or day-roosting, was located, we established a 10m×10m plot with the foraging or day-roosting site as the center to measure variables for trees. We then subdivided these plots into four 5m×5m sections to document shrubs, and we used five 1m×1m sections (one at each corner and

Table I. Distribution frequencies of categorical variables for foraging or day-roosting sites of brown-eared pheasants during autumn 2018 in Huanglong Mountains, Shaanxi Province, China.

Factors	Category	Frequency			Percentage (%)		
		Foraging	Day-roosting	Control plots	Foraging	Day-roosting	Control plots
Vegetation type	Broadleaved forest	50	20	38	59.52	24.39	24.83
	Mix forest	28	35	57	33.33	42.68	37.25
	Conifer forest	6	27	58	7.14	32.93	37.91
Slope location	Upper slope	50	39	51	59.52	47.56	33.33
	Mid slope	26	16	35	30.95	19.51	22.88
	Lower slope	8	27	67	9.52	32.93	43.79
Slope aspect	Sunny slope	41	47	79	48.81	57.32	51.63
	Mid sunny slope	38	29	69	45.24	35.36	45.09
	Shady slope	5	6	53	5.95	7.32	3.27
Landform type	Gully	32	19	41	38.10	23.17	26.79
	Slope side	42	25	85	50.00	30.49	55.55
	Ridge	10	38	27	11.90	46.34	17.65

Table II. Characteristics of 15 ecological factors at foraging and day-roosting habitat used by brown-eared pheasant during Autumn 2018 in Huanglong Mountains, Shaanxi Province, China.

Variables	Foraging samples (n=84)	Day-roosting samples (n=82)	Random samples (n=153)	Foraging vs. random	Day-roosting vs. random
Altitude (m)	1354.86±10.65	1348.48±10.20	1300.21±8.49	T = 3.863**	T =3.497**
Slope degree (°)	24.38±0.69	21.79±0.86	20.49±0.47	T = 4.720**	T = 1.436
Distance to water (m)	368.86±19.93	353.27±15.08	347.30±19.85	Z = -1.140	Z = -1.037
Distance to household (m)	440.43±23.73	455.44±24.49	391.95±12.23	T = -1.407*	Z = -2.099*
Distance to woodside (m)	339.57±20.88	117.30±12.22	440.95±28.76	Z = -1.013	Z = -8.345**
Tree cover (%)	0.41±0.02	0.39±0.02	0.48±0.01	Z = -2.132*	Z = -3.166**
Tree density (inds/m^2)	5.74±0.54	5.87±0.55	8.15±0.37	Z = -4.473**	Z = -4.250**
Tree diameter (cm)	22.48±1.26	20.03±1.13	19.39±0.54	T = -2.600**	T = 0.574
Tree height (m)	9.18±0.38	9.35±0.37	10.80±0.19	Z = -3.643**	Z = -3.404**
Shrub cover (%)	0.39±0.02	0.37±0.02	0.44±0.01	Z = -2.509*	Z = -3.171**
Shrub density (inds/m^2)	2.64±0.14	2.70±0.15	2.29±0.09	T = 2.107*	T = 2.279*
Shrub height (m)	1.59±0.04	1.46±0.04	1.60±0.03	T = -0.405	T = -3.057**
Herb cover (%)	0.25±0.02	0.20±0.01	0.19±0.01	Z = -2.987**	Z = -1.672
Herb height (cm)	10.84±0.46	11.53±0.54	13.19±0.32	T = -4.253**	T = -2.810**
Sheltering class (%)	0.38±0.03	0.11±0.54	0.25±0.01	Z = -2.802**	Z = -7.697**

Note: *P<0.05 **P<0.01. T, Independent-sample *T*-test; U, Mann-Whitney *U*-test.

one at the center of the 10m×10m plot) for herbs. When appropriate, values from each plot subsection were averaged to obtain a value for the entire plot. Finally, we recorded four categorical assignments to each plot, and measured 15 continuous variables (Tables I and II): the four categorical factors were (1)Vegetation type (broadleaved forest, coniferous forest, or mixed forest); (2) Slope aspect (sunny, mid sunny slope, or shaded); (3) Slope location (upper, middle, or low); (4) Landform type (gully, slope side, or ridge). The 15 continuous variables were measured based on published literature (Lu and Zheng, 2002, 2003): elevation (measured with a GPS receiver); degree of slope (measured with a compass); tree cover (%); shrub cover (%); herb cover (%); tree diameter (cm) at breast height of 1.3 m; tree height (m); tree density (inds/m^2); shrub height (m); shrub density (inds/m^2), herb height (cm); distance to water (m); distance to household (m); distance to woodside (m) and sheltering class (%). We evaluated percentage cover with an ocular tube (Lu and Zheng, 2003).

To compare the characteristics of used sites with those of surrounding areas, some control samples were established. In order to ensure the randomness of the control sample, we made 10m×10m plots along each transect at intervals of 200m according to the above method. Following the above measuring method, the four categorical and 15 continuous variables were measured. In addition, if the pheasant's foraging or day-roosting site was found in the control sample, we rejected it.

Statistical analyses

For four categorical factors, the chi-square test was used to quantify goodness-of-fit of utilized habitats to available habitat (Neu *et al*., 1974). All 15 numeric ecological data were first tested for normality (Kolmogorov-Smirnov Test). Independent-sample *T*-test was then used for normal data and Mann-Whitney *U*-test when data were not normally distributed. All variables that differed between used sites and the control ones, were retained. Finally, stepwise discriminant analysis was performed to determine the key decisive factor of habitat selection. Wilk's K value was selected as discriminant index of used sites and the control ones of the brown-eared pheasant, the smaller the value the stronger discriminant ability. A probability of 0.05 or less was accepted as significant difference; values are presented as mean ± standard error. All statistical analyses were conducted in SPSS 19.0 for Windows.

RESULTS

Habitat preferences of the brown-eared pheasant

During the survey period, we found 84 foraging, 82 day-roosting and 153 random sampling sites. Of 84 foraging sites (Table I), there is highly significant difference in vegetation type (χ^2 = 21.278, df = 2, P = 0.000 < 0.01), in slope location (χ^2 = 42.208, df = 2, P = 0.000 < 0.01), and significant difference in landform types (χ^2 = 6.044, df = 2, P = 0.049 < 0.05), and non-significant difference in slope aspect (χ^2 = 1.978, df = 2, P = 0.372 > 0.05) between foraging and random sites of brown-eared pheasants in autumn. These results show that brown-eared pheasant preferred foraging in areas characterized by broad leaved forest, mid and upper slope location, and gully. Of 82 day-roosting sites (Table I), there was highly significant difference in landform types (χ^2 = 47.913, df = 2, P = 0.000 < 0.01), significant difference in slope location (χ^2 = 7.599, df = 2, P = 0.022 < 0.05), in slope aspect (χ^2 = 6.340, df = 2, P = 0.042 < 0.05) and non-significant difference in vegetation type (χ^2 = 1.193, df = 2, P = 0.551 > 0.05) between day-roosting and random sites. These results also show that brown-eared pheasant preferred day-roosting in areas where they were characterized by ridge, upper slope location, and sunny slope.

Meanwhile, compared with the control sites, except for distance to water and woodside, and shrub height, there are highly significant or significant differences in other numeric ecological factors between foraging and random sites, while between day-roosting and random sites there are highly significant or significant differences except for slope degree, distance to water, trees diameter and herb cover in autumn. These results show that brown-eared pheasants prefer to foraging at a higher altitude, steeper slope, longer distance to household, less cover, height and density and bigger diameter of trees, less cover and bigger density of shrub, bigger cover and less height of herb, and higher sheltering class. The brown-eared pheasants prefer to day-roosting at a higher altitude, longer distance to household and closer distance from the woodside, less tree cover, density and height, less cover, height, bigger density of shrub, less height of herbs and less sheltering class.

Main factors affecting habitat selection of brown-eared pheasant

Results of stepwise discriminant analysis on foraging sites selection showed an eigenvalue of 0.656, canonical correlation coefficient of 0.629, which contains all the variance (100%), meanwhile, value of Wilks'K also suggested a highly significant difference between foraging and control sites selection (Wilks'K = 0.607, χ^2 = 115.476, df = 715, P = 0.000 < 0.001). Hence a higher degree of separation is between foraging and random sites in the canonical coefficient histogram. The results showed that seven ecological factors played a role in distinguishing the foraging and random sites, in accordance with the order of its contribution value: altitude, slope degree, trees height, tree diameter, shrub cover, herb height and sheltering class (Table III). Based on the above ecological variables, the correct distinguish rate on foraging and random sites reached 90.2%. According to the above-mentioned methods, eight ecological factors including altitude, tree cover, shrub cover, shrub height, herb height, sheltering class, and distance to household and woodside play a role in distinguishing the day-roosting and random sites (Table III), and the correct distinguish rate on day-roosting and random sites reached values as high as 88.90%.

Table III. Stepwise discriminant analysis of ecological factors in foraging and day-roosting sites used by brown-eared pheasant during Autumn 2018 in Huanglong Mountains, Shaanxi Province, China.

Habitat type	Variable No	Variables	Discriminant coefficients	Wilks' λ	Significance
Foraging sites	1	Altitude (m)	0.351	0.905	≤0.001
	2	Slope degree (°)	0.332	0.823	≤0.001
	3	Tree height (m)	-0.729	0.770	≤0.001
	4	Tree diameter (cm)	0.714	0.731	≤0.001
	5	Shrub cover (%)	-0.243	0.703	≤0.001
	6	Herb height (cm)	-0.346	0.618	≤0.001
	7	Sheltering class (%)	0.493	0.604	≤0.001
Day-roosting	1	Altitude (m)	-0.269	0.783	≤0.001
	2	Tree cover (%)	0.265	0.656	≤0.001
	3	Shrub cover (%)	0.206	0.596	≤0.001
	4	Shrub height (m)	0.419	0.554	≤0.001
	5	Herb height (cm)	0.199	0.530	≤0.001
	6	Sheltering class (%)	0.516	0.514	≤0.001
	7	Distance to household (m)	-0.264	0.503	≤0.001
	8	Distance to woodside (m)	0.774	0.493	≤0.001

Highly Significant different (P<0.01).

DISCUSSION

It is generally believed that habitat quality can directly affect the distribution of animals, their population density, and reproductive and survival rates (Cody, 1985). As far as many pheasants are concerned, their daily activities include two processes of foraging and day-resting during autumn periods (Liu *et al*., 1991; Li *et al*., 2008) and consequently these pheasants must choose their foraging and roosting sites carefully because the ability of their weak flight and diffusion made most of their behaviors limited to the ground environment, which makes them difficult to expand in vertical space (Deng and Zheng, 2004; Xu *et al*., 2010; Xia *et al*., 2019). The brown-eared pheasant preferred to foraging in areas which were characterized by broadleaved forest, mid and upper slope location, and gully (Table I). We suspect that this preference may be a result of food abundance. Within broadleaved forests, we noted a large number of liaodong oak (*Quercus wutaishan sea*) and nippon hawthorn (*Crataegus cuneata*), in mid and upper slope location of Huanglong Mountains, which produces fruits that are often consumed by the birds. And it tends to eat in the gully because there is higher abundance of fruits rolled from high places. The brown-eared pheasant preferred to day-roosting in areas which were characterized by ridge, upper slope location, and sunny slope (Table I). These differences in the choice of foraging and day-roosting sites can be due to predators. Day-roosting sites in ridge location are good for spotting enemies in advance to escape towards both sides of the ridge and the upper slope location may avoid the interference of human farming activities. And day-roosting sites tend to be found on sunny slopes because the soil there is relatively dry.

It has been shown that food, concealment and water source are the three main factors of wildlife habitat selection, which directly affect wildlife habitat selection (Song *et al*., 1998; Johnsgard, 1999; Alves *et al*., 2017). Throughout the autumn, the brown-eared pheasant demonstrated a preference for higher altitude, indicating that the birds used habitats in upper slope location that best met their ecological requirements during this period. The other possible reason probably is that after summer there are many subadults in chicken flocks, which have poor motor ability to evade the predators, especially human activities. In the selection of foraging sites, the brown-eared pheasant also demonstrated a preference for steep slope degree, bigger tree height and diameter, smaller shrub cover and lower herb height, and higher sheltering class (Tables II and III). The large trees with higher height and diameter produce large amont of fruits and the steep slope is conducive to the accumulation of fruit below, so that the birds can improve feeding efficiency. This is consistent with the optimal foraging theory that an animal should forage in areas where its intake rate is the highest and predation risk the lowest (Houtman and Dill, 1998). The smaller shrub cover and lower herb height may help to spot predators in advance and escape rapidly to higher sheltering class, which is measured 20 meters away, to make sure that the bird has enough time to spot predators.

In the selection of day-roosting sites, the brown-eared pheasant also demonstrated a preference for smaller tree cover, lower shrub cover and height, lower herb height and sheltering class, far away from households, and close to woodside. The brown-eared pheasant exhibited an attraction to edge habitats, which may be related to the fact that day-roosting near woodside is conducive to get sunlight and escape from predators, on the contrary, other factors including smaller tree cover, lower shrub cover and height and lower herb height make the birds obviously exposed to natural enemies, such as eagles (*Accipiter gentilis*), golden eagles (*Aquila chrysaetos*) and vultures (*Aegypius monachus*) in the air. Lower sheltering class further proves the poor shade degree of day-roosting sites. This day-roosting site selection probably is the outcome of the trade-offs between predator avoidance and sunlight acquisition (Lima and Dill, 1990). Moreover, water source is one of the factors affecting wildlife habitat selection (Song *et al*.,1998; Alves *et al*., 2017). In Huanglong Mountains during autumn periods, a lot of berries, such as *Hippophae rhamnoides*, *Viscum coloratum*, eaten by the brown-eared pheasant may replenish the water requirement of the bird, besides, morning dew can also provide some moisture. Therefore, water source is not a key ecological factor in the autumn.

ACKNOWLEDGEMENTS

We are grateful to the Huanglongshan Nature Reserve for the support in the study. We especially thank Zhonghou Chen and Simeng Zhang, at the School of modern agriculture and Bioengineering of Yangtze Normal University, for assistance in the field and two anonymous referees for their critical comments which improved this manuscript. The project was financially supported by the National Natural Science Fund Project, grant number 31870515, Excellent Achievement Transformation Project in Universities of Chongqing, grant number KJZH17132, Basic Research and Frontier Exploration of Chongqing Science and Technology Commission, grant number cstc2018jcyjAX0557.

Statement of conflict of interest

The Authors have declared no conflict of interest.

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