Bird Conservation International (2005) 15:303–312.
doi:10.1017/S095927090500047X Printed in the United Kingdom

Winter habitat requirements of White Eared-pheasant *Crossoptilon crossoptilon* and Blood Pheasant *Ithaginis cruentus* in south-west China

FEI JIA, NAN WANG and GUANG-MEI ZHENG

Summary

Understanding the habitat needs of White Eared-pheasant *Crossoptilon crossoptilon* and Blood Pheasant *Ithaginis cruentus* is important for their conservation. We carried out field surveys of the two pheasants around Zhujie Monastery, Daocheng County, Sichuan Province, China, using line transects. In total, 172 200 × 200 m grid squares were obtained, including 56 active and 116 inactive ones for White Eared-pheasant and 45 active and 127 inactive ones for Blood Pheasant. We analysed the occurrence of both species by logistic multiple regression. The most important variables in model 1 for White Eared-pheasant were distance to nearest permanent water, shrub cover, tree cover, tree height and herb cover. In model 2 for Blood Pheasant, distance to nearest permanent water, shrub cover, herb cover and herb height were most important. The occurrence of both pheasants was negatively related to distance to nearest permanent water and herb cover, and positively related to shrub cover. The occurrence of White Eared-pheasant was positively related to tree cover and tree height, and that of Blood Pheasant to herb height. Water, food and predation risk were the main ecological factors affecting the species' distribution. Based on the two predictive models, conservation management was proposed, to include management of selectively-logged areas and substituting other energy sources, such as electricity, for firewood.

Introduction

White Eared-pheasant *Crossoptilon crossoptilon* and Blood Pheasant *Ithaginis cruentus* are respectively listed in CITES Appendix I and II (2003) and as national second-grade wildlife for protection of China (Zheng and Wang 1998). They are found mainly in south-west China and occur in coniferous forests, coniferous-deciduous forests and subalpine shrubs (Cheng *et al.* 1978). White Eared-pheasant typically inhabits areas from 3,000 to 4,300 m a.s.l. and Blood Pheasant from 2,000 to 3,500 m (Cheng *et al*. 1978).

Gema *et al*. (1999) described White Eared-pheasant habitat as conifer forests (*Picea* spp.), conifer-deciduous mixed forest and shrub (*Rhododendron* spp.). Lu and Zheng (2001, 2002) found that a congener, Tibetan Eared-pheasant *Crossoptilon harmani*, preferred coniferous-deciduous forest and scrub environments, and provided information on this species' reproductive ecology (egg morphology, egg size, clutch size, reproductive success and nest-site habitat (Lu and Zheng 2003). Jia *et al*. (1999, 2000, 2003) studied habit, social organization and breeding biology of Blood Pheasant, but there have been no detailed studies of habitat selection of the two species.

As common linear models cannot successfully predict distribution (Morrison *et al.* 1987), predictive models for animal distribution, including logistic regression, have been applied and developed in recent years (Augustin *et al.* 1996, Boyce and MacDonald 1999, Guisan and Zimmermann 2000, Pearce and Ferrier 2000, Manel *et al.* 2001, Boyce *et al.* 2002). Logistic regression was first used in multivariable analysis in 1967 (Hosmer and Leweshow 1989), since when it has been a standard method for dichotomous data regression analysis in many fields. Recently many studies on birds have applied this method to assess habitat selection and predict distribution (Osborne and Tigar 1992, Li *et al.* 1999, Franco *et al.* 2000, McFaden and Capen 2002). One obvious characteristic of these studies was that logistic regression allowed multiple factors to be analysed together, to predict the animal's distribution.

The aim of this study, therefore, was to characterize the habitat preferences of the two species, using logistic regression to study habitat selection and predict their distribution. We hypothesized that some differences in habitat preferences between these two sympatric species should exist.

Methods

Fieldwork was conducted during January to April 2003 around Zhujie Monastery (29°09′N, 100°10′E) in Daocheng County, Sichuan Province, China (Figure 1). Zhujie Monastery lies in the central part of the Hengduan mountains. White Eared-pheasant and Blood Pheasant occur together in the study area. The study area comprised 688 ha on a south-facing slope of 3,850 m to 4,900 m in elevation. The study area was dominated by oak *Quercus apuifolioides* trees and shrubs, surrounded by farmland, meadow and rocks. Understorey vegetation was sparse, with few shrubs or herbs. We divided the study area into three parts: the higher elevations (4,300–4,900 m) were dominated by ice and rocks, the mid-elevations (3,900–4,300 m) by oak trees and

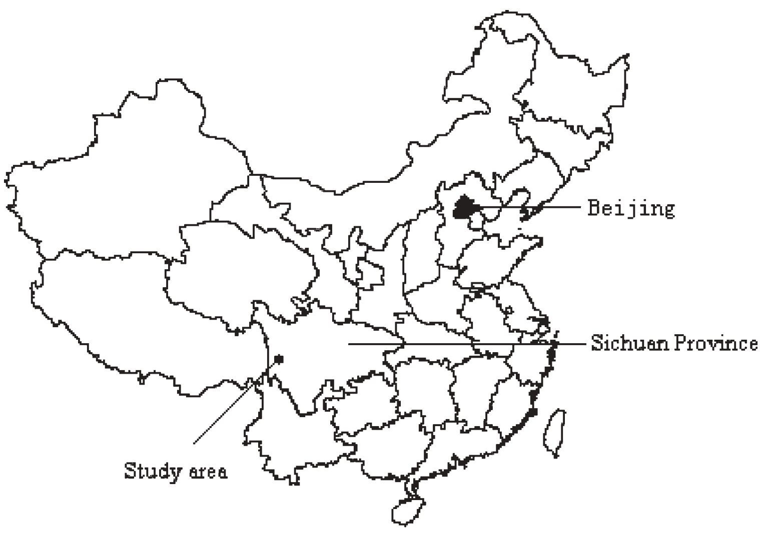

Figure 1. Location of the study area in Daocheng County, Sichuan Province, China.

https://doi.org/10.1017/S095927090500047X Published online by Cambridge University Press

shrubs, and the lower elevations (3,850–3,900 m) by meadows, village and farmland. Several unpaved roads connect the village with Zhujie Monastery. Three streams originating from the melting ice on the top of the mountain bisected the study area. Mean annual temperature in the area is 8.5 °C and mean annual precipitation is 1,130 mm.

We divided the study area into 172 grid squares, each 200 × 200 m. We used line transects to traverse the entire study area to determine the presence of each species in the grid squares. Each transect line was surveyed twice during the whole survey period, to reduce the underestimation of presence. In addition, in order to find more individuals of the two species, we randomly selected some transects that ran obliquely up and down the mountain to cover the altitudinal range of a specific plant community (Lu and Zheng 2001).

Our surveys were conducted from 08h00 to 12h00 and from 14h00 to 19h00 each day and we did not survey during periods of inclement weather. Our walking speed averaged 1.5–2.0 km/h. We walked several west–east transects at intervals of 200 m, and obtained a 200 × 200 m grid every 200 m by using perpendicular transects. When we walked along each transect we recorded the number and the positions of individuals of each species within 50 m of both sides of the transect line. Both White Eared-pheasant and Blood Pheasant were rarely disturbed by human presence even if the distance from human to pheasant was only 10 m (pers. obs.) The vegetation cover in the study area was sparse; therefore, both species were easy to observe.

According to our field experience and the methods provided by Lu and Zheng (2001) and Xu *et al*. (2002), we randomly made nine 10 × 10 m plots to measure variables for trees, five 2 × 2 m plots in each 10 × 10 m plot for shrubs and two 1 × 1 m plots in each 2 × 2 m plot for herbs in each grid. Based on our field observations and information on White Eared-pheasant and Blood Pheasant, we measured the following variables among the great number of habitat characteristics that may have affected the distribution of the two species: latitude and longitude (measured with a GPS receiver); elevation (measured with an altimeter); degree of slope (measured with a clinometer); aspect of slope (measured with a compass); tree cover (%); shrub cover (%); herb cover (%); tree diameter at breast height (cm); tree height (m); shrub height (m); herb height (cm); distance to nearest permanent water (m); distance to nearest human settlement (m); distance to nearest unpaved road (m); cover of fallen leaves (%) and depth of fallen leaves (cm). In each plot, we estimated percentage cover with an ocular tube, and measured the height of plants using an altimeter (for trees) and a ruler (for shrubs and herbs) (Lu and Zheng 2001). Mean values of the above variables measured in all plots of each grid represented the values for the grid.

Data analysis

We defined a dichotomous response variable as '0' if the species was absent from the grid (inactive grids) and '1' if at least one individual was present in the grid (active grids). In all the 172 grid squares, 64 were surveyed nine times during the whole study period. By using the program PRESENCE (developed by Darryl Mackenzie of Proteus Research & Consulting), we calculated single-season detection probabilities of the two species based on whether they were found in the above 64 grid squares on each survey. Independent-sample *t*-tests were used to determine the variables with significant differences between active and inactive grids if the data met assumptions of normality (one-sample Kolmogorov–Smirnov test, $P > 0.05$), and Mann–Whitney U-tests were used if not (Xu *et al.* 2002). Spearman rank correlations (two-tailed) were used to determine whether these variables were correlated. If the absolute values of correlation coefficients among the above variables were equal to or more than 0.60, the important variables in biological implications were retained (Lahaye and Gutierrez 1999). We used Moran's I coefficients of the retained variables to assess spatial autocorrelation (Turner *et al.* 1990). The retained variables, as independent variables, were used to conduct logistic regression models (Method: Enter) (Augustin *et al.* 1996, Li *et al.* 1999, Franco *et al.* 2000). According to the methods provided by Hosmer and Leweshow (1989), Li *et al.* (1999) and Wang (2003), we conducted Hosmer and Leweshow tests, calculated the values of optimal cut-off points and the values of m_1, m_2, n_1, n_2, mn_1, mn_2 and n for the two models in order to assess their goodness-of-fit. Finally, we mapped the probabilities of occurrence for the two pheasants in the study area according to the two logistic regression equations by using the software ArcView GIS 3.2 (Environmental Systems Research Institute, 1999). We used SPSS10.0.1 for Windows (SPSS, 1999) to conduct all statistical analysis.

Results

Habitat preferences

The proportions of sites occupied by White Eared-pheasant and Blood Pheasant respectively were 0.891 and 0.781, and detection probabilities were 0.819 and 0.753. Environmental variables were not normally distributed, and all efforts to transform them failed. Therefore, Mann–Whitney U-tests was used. For White Eared-pheasant, distance to nearest permanent water, shrub cover, shrub height, tree cover, tree height, tree diameter at breast height and herb cover differed significantly between active and inactive grids. For Blood Pheasant, distance to nearest permanent water, shrub cover, shrub height, herb cover and herb height differed significantly (Table 1). Based on the absolute values of correlation coefficients and the biological implications of the above variables (Table 2), we retained distance to nearest permanent water, shrub cover, tree cover, tree height and herb cover as independent variables in

Table 1. Variables influencing presence/absence of White Eared-pheasant and Blood Pheasant between grid squares in south-west China, January–April 2003.

Variable	White Eared-pheasant		Blood Pleasant	
	Z value	P value	Z value	P value
Distance to nearest permanent water	−3.516	0.000	−6.515	0.000
Shrub cover	−3.705	0.000	−5.208	0.000
Shrub height	−4.385	0.000	−4.985	0.000
Tree cover	−7.354	0.000	−1.147	0.251
Tree height	−7.303	0.000	−1.097	0.273
Tree diameter at breast height	−7.184	0.000	−1.035	0.301
Herb cover	−3.428	0.000	−2.398	0.017
Herb height	−1.943	0.052	−2.312	0.021
Distance to human settlement	−0.259	0.795	−0.777	0.437
Distance to nearest unpaved road	−1.918	0.055	−0.532	0.595

Significance was determined using Mann–Whitney U–tests.

Table 2. Correlation coefficients of variables important in influencing presence/absence of White Eared-pheasant and Blood Pheasant between grid squares in south-west China, January–April 2003.

Variable	Shrub cover	Shrub cover	Tree cover	Tree height	Tree diameter at breast height	Herb cover	Herb height
Distance to nearest permanent water	–0.303**	–0.302**	0.011^{ns}	0.007^{ns}	0.014^{ns}	0.006^{ns}	–0.188*
Shrub cover	–	0.840**	–0.377**	–0.361**	–0.360**	–0.177**	0.523**
Shrub height	–	–	–0.079^{ns}	–0.075^{ns}	–0.067^{ns}	–0.239**	0.522**
Tree cover	–	–	–	0.994**	0.992**	–0.315**	0.023^{ns}
Tree height	–	–	–	–	0.996**	–0.302**	0.038^{ns}
Tree diameter at breast height	–	–	–		–	–0.299**	0.043^{ns}
Herb cover	–	–	–	–		–	0.083^{ns}

^{ns}No significant difference; *$P < 0.05$; **$P < 0.01$.

Table 3. Moran's *I* coefficients for the remained variables and results of logistic regression for White Eared-pheasant in model 1 and Blood Pheasant in model 2 in south-west China, January–April 2003.

Variable	Moran's *I*	Model 1		Model 2	
		Coefficient	Wald's value	Coefficient	Wald's value
Distance to nearest permanent water	0.096	–0.005	11.698	–0.009	27.525
Shrub cover	0.105	0.018	4.317	0.023	6.940
Tree cover	0.151	0.178	1.074	–	–
Tree height	0.139	0.296	0.510	–	–
Herb cover	0.154	–0.006	0.842	–0.019	6.387
Herb height	0.214	–	–	0.052	0.160
Constant	–	–0.352	0.427	0.947	3.459

the logistic regression for White Eared-pheasant, and distance to nearest permanent water, shrub cover, herb cover and herb height for Blood Pheasant.

In all, 179 White Eared-pheasant observations were made in 56 grids, and 84 Blood Pheasant observations in 45 grids (i.e. 56 active and 116 inactive White Eared-pheasant grids; 45 active and 127 inactive Blood Pheasant grids). Moran's *I* coefficients for the retained variables were rather low (Table 3), which suggested that the lag we designed was reasonable. We obtained logistic regression models for both species (Table 3). The occurrence of the two pheasants was negatively related to distance to nearest permanent water and herb cover, and positively related to shrub cover. The occurrence of White Eared-pheasant was positively related to tree cover and tree height and that of Blood Pheasant to herb height.

Assessing goodness-of-fit

Hosmer and Leweshow goodness-of-fit tests divided subjects into deciles based on predicted probability, then computed a chi-square from observed and expected frequencies. *P* values of the models (model 1: $\chi^2 = 6.829$, df = 8, $P = 0.555$; model 2: $\chi^2 = 11.583$, df = 8, $P = 0.171$) were computed from the chi-square distribution with eight degrees of freedom and indicated that the logistic models for the species were good fits (Hosmer and Leweshow 1989). Results also showed that cut-off points that optimized the correct classifications were 0.3 for the two models. For White Eared-pheasant ($m_1 = 45$; $n_1 = 11$; $mn_1 = 56$; $n_2 = 25$; $m_2 = 91$; $mn_2 = 116$; $n = 172$), CT ($[m_1 + m_2]/n$) was 79.1%, which was considered as the accuracy of the model; CP (m_1/mn_1) for grids observed to be active was 80.4%; CA (m_2/mn_2) for grids observed to be inactive was 78.4%. For Blood Pheasant ($m_1 = 37$; $n_1 = 8$; $mn_1 = 45$; $n_2 = 24$; $m_2 = 103$; $mn_2 = 127$; $n = 172$), the values of CT, CP and CA were 81.4%, 82.2% and 81.1%, respectively. The values of CT, CP and CA for the two models showed that they both had a generally satisfactory accuracy. Probabilities of occurrence for the two pheasants according to the two logistic regression equations were consistent with our observations (Figure 2).

Discussion

The use of presence/absence data in wildlife management and biological survey is frequent, but there is growing interest in quantifying the sources of error associated with these data. Tyre *et al.* (2003) showed that false-negative errors (failure to record a species when in fact it was present) could have a significant impact on statistical estimation of habitat models using simulated data. We could correct estimates of the probability of occurrence for false-negative errors by repeating visits. Up to 6 times the effort might be required to correct for the presence of false-negative errors in presence–absence data (Tyre *et al.* 2003). The relatively high detection probabilities of White Eared-pheasant and Blood Pheasant and the nine visits made to some grid squares ensured that our results for habitat selection by the two species were precise and reliable.

The selected models predicted the distribution of the species well. Most White Eared-pheasant and Blood Pheasant observation points were located in areas with high probabilities of occurrence. Both species preferred sites close to water, with higher shrub cover and lower herb cover. White Eared-pheasant occurred in woodland while Blood Pheasant seldom did. Blood Pheasant preferred the sites with higher herb height but this was not important for White Eared-pheasant. The above differences in habitat preference between the two species supported our previous assumption.

The presence of both species was closely related to water, as noted by previous studies on White Eared-pheasant (Lu and Zheng 2001, 2002) and Blood Pheasant (Jia *et al.* 1999, 2000). Solar radiation and south-facing slopes result in most of the study area being rather dry and the relatively dense shrubs near streams result in more abundant food and better shelter. As a result, areas near stream belts were the preferred habitat (Lu and Zheng 2001, Jia *et al.* 2003). Other studies confirm such associations between galliformes and wet areas (Sather-Blair and Liner 1980, Young *et al.* 1991). Both species preferred sites with higher shrub cover, confirming previous studies on White Eared-pheasant (Lu and Zheng 2001, 2002) and Blood Pheasant (Jia *et al.* 2003). According to our observations, the two pheasants were at a higher risk of predation by Himalayan Griffon *Gyps himalayensis*. High shrub cover may play a key role in providing refuge (Lu and Zheng 2002, Jia *et al.* 2000). We also detect a significant negative relationship between the presence of the two pheasants and herb cover, suggesting the two birds seldom venture into meadows. Open fields can put eared-pheasants at higher predation risk (Lu and Zheng 2001). Bland and

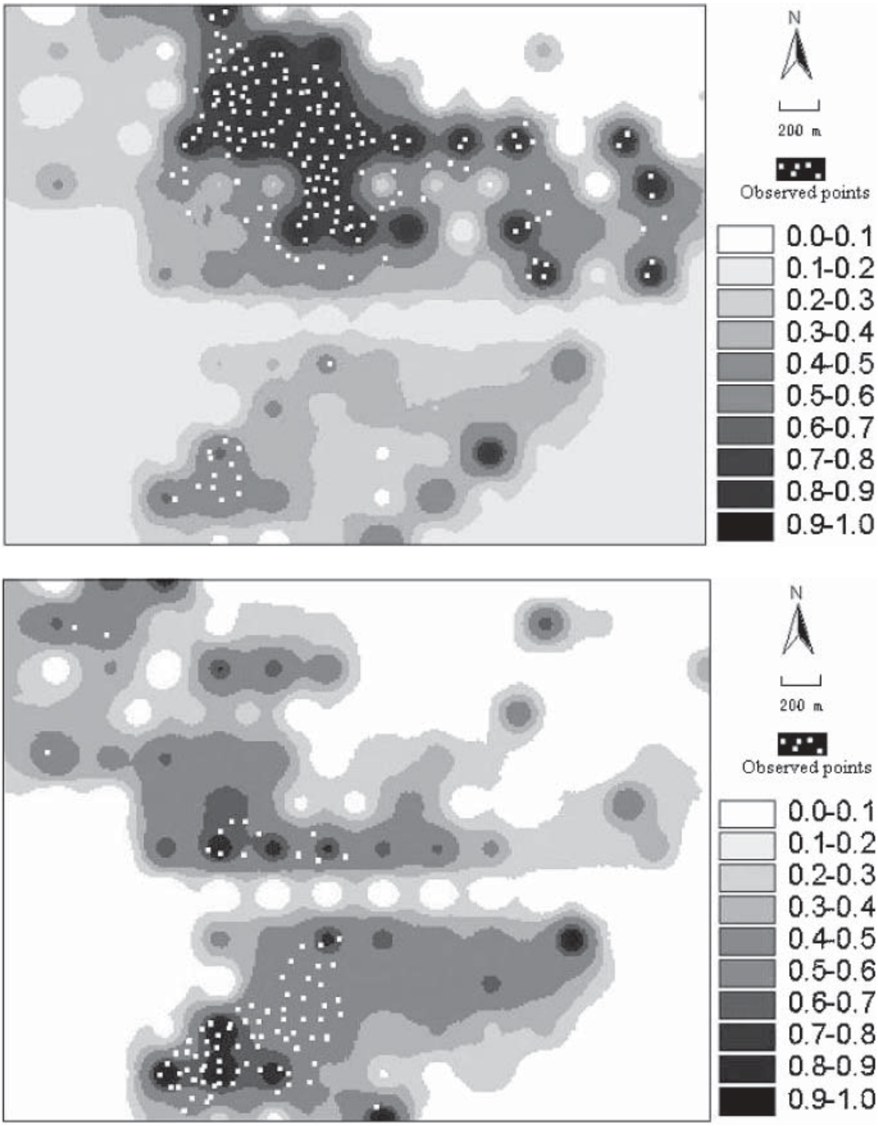

Figure 2. (*a*) Probability of occurrence of White Eared-pheasant in the study area according to the logistic regression equation of model 1. (*b*) Probability of occurrence of Blood Pheasant in the study area according to the logistic regression equation of model 2.

Temple (1990) demonstrated that raptors have a strong influence on habitat use by birds feeding in open fields. In addition, grazing cattle in the meadows might affect use by both species. This has been reported in Vietnam where grazing cattle have a strong negative effect on Green Peafowl *Pavo muticus* (Brickle 2002).

The fact that wooded areas are the preferred sites of White Eared-pheasant is confirmed by some previous studies (Gema *et al.* 1999, Lu and Zheng 2001, 2002). However, studies have also shown this to be the case for Blood Pheasant (Jia *et al.*

https://doi.org/10.1017/S095927090500047X Published online by Cambridge University Press

1999, 2000), which is not consistent with our study. We speculate that this discrepancy can be attributed to the layer structure of trees. Previous studies were in forest with a relatively dense understorey (Jia *et al.* 2000), providing foraging places for pheasants pecking plants near the ground (Jia *et al.* 2003). However, almost no understorey vegetation was found in wooded areas in our study. Shrub and herb cover were significantly negatively correlated with tree cover. We deduce that the shortage of available food near the ground in wooded areas causes Blood Pheasant to be absent from such places. On the other hand, this sparse understorey in woodland had little effect on the foraging of White Eared-pheasant, which digs up plant roots and invertebrates in the soil, because these are still available (Lu and Zheng 2001). In fact, much of the ground in woodland in our study area was dug up by White Eared-pheasants. We suggest that foraging differences between the two pheasants is one possible reason for the differences in habitat use.

Our study only included permanent water, not temporary water bodies. This may have led to an underestimate of suitable habitat for the two pheasants in some areas. Habitat use depends on more complex sets of subtle cues than indicated by the two models. Further research is needed to improve our understanding of habitat preferences. This study could have been improved by using polytomous regression that considers more than two categories for the response variable (Franco *et al.* 2000).

Nevertheless, the two models are useful tools for proposing conservation actions for the two species in the study area. Although the variables of distance to nearest human settlement and distance to nearest unpaved road were not important factors, the development of local tourism may affect these species in the future. With the development of the national economy and the improvement in transport, increasing numbers of tourists will visit the village and the monastery. Tourism can support the development of the local economy, but more tourists will require greater amounts of firewood for heating and cooking. This may increase firewood collection and possibly damage woodland habitats. However, it is not possible to completely prohibit logging activities because local natural resources are limited. As a result, selective logging activities should be encouraged. The value of selectively-logged areas can remain high if illegal logging and firewood collection are strictly controlled. Additionally, other sources of energy, such as electricity could substitute for firewood to some extent.

Acknowledgements

This study was supported by National Sciences Foundation of China (No. 30330050) and Chicago Zoological Society's Chicago Board of Trade Endangered Species Fund. We thank Professor Zhang Zhen-wang, Dr Deng Wen-hong and Dr Xu Ji-liang, who provided great assistance in the writing of this paper. We also thank Sichuan Province Forestry Bureau, Daocheng County Forestry Bureau and Daocheng County Religion Bureau. Finally, we thank the monks Geli, Dengba and Kaoli who gave us enthusiastic and effective assistance in the field.

References

Augustin, N. H., Mugglestone, M. A. and Buckland, S. T. (1996) An autologistic model for spatial distribution of wildlife. *J. Appl. Ecol.* 33: 339–347.

Bland, J. D. and Temple, S. A. (1990) Effects of predation-risk on habitat use by Himalayan Snowcocks. *Oecologia* 82: 187–191.

Boyce, M. S. and MacDonald, L. L. (1999) Relating populations to habitats using resource selection functions. *Trends Ecol. Evol.* 14: 268–272.

Boyce, M. S., Vernier, P. R., Nielsen, S. E. and Schmiegelow, F. K. A. (2002) Evaluating resource selection functions. *Ecol. Model.* 157: 281–300.

Brickle, N. W. (2002) Habitat use, predicted distribution and conservation of Green Peafowl *Pavo muticus* in Dak Lak Province, Vietnam. *Biol. Conserv.* 105: 189–197.

Cheng, T. H., Tan, Y. K. and Lu, T. C. (1978) *Fauna of China. Aves.* Volume IV. *Galliformes.* Beijing: Science Press.

Franco, A. M. A., Brito, J. C. and Almeida, J. (2000) Modeling habitat selection of Common Cranes *Grus grus* wintering in Portugal using multiple logistic regression. *Ibis* 142: 351–358.

Gema, J. C., Dong, D. F. and Long, W. X. (1999) A preliminary study of the ecology of White Eared-pheasant. *Chin. J. Zool.* 34(1): 26–28.

Guisan, A. and Zimmermann, N. E. (2000) Predictive habitat distribution models in ecology. *Ecol. Model.* 135: 147–186.

Hosmer, D. W. and Leweshow, S. (1989) *Applied logistic regression*. New York: Wiley.

Jia, C. X., Zheng, G. M., Zhou X. P. and Zhang, H. M. (1999) Social organization of Blood Pheasant *Ithaginis cruentus* in Wolong Nature Reserve, China. *Acta Zool. Sinica* 45(2): 135–142.

Jia, C. X., Sun, Y. H. and Fang, Y. (2000) Occurrence of the Blood Pheasant *Ithaginis Cruentus* in relation to habitat fragmentation in southern Gansu, China. Pp. 86–90 in M. Woodburn and P. McGown, eds. *Galliformes 2000: Proceedings of the 2nd International Galliformes Symposium*. Nepal: Kathmandu and Royal Chitwan National Park.

Jia, C. X., Zheng, G. M., Zhou, X. P. and Zhang, H. M. (2003) Analysis behavior characteristics of Blood Pheasant during breeding period in Wolong. *Chin. J. Zool.* 38(1): 37–42.

Lahaye, W. S. and Gutierrez, R. J. (1999) Nest sites and nesting habitat of the Northern Spotted Owl in northwestern California. *Condor* 101: 324–330.

Li, W. J., Wang, Z. J., Ma, Z. J. and Tang, H. X. (1999) Designing the core zone in a biosphere reserve based on suitable habitats: Yancheng Biosphere Reserve and the Red Crowned Crane *Grus japonensis*. *Biol. Conserv.* 90: 167–173.

Lu, X. and Zheng, G. M. (2001) Habitat selection and use by a hybrid of White and Tibetan eared pheasants in eastern Tibet during the post-incubation period. *Can. J. Zool.* 79: 319–324.

Lu, X. and Zheng, G. M. (2002) Habitat use of Tibetan Eared Pheasant *Crossoptilion harmani* flocks in the non-breeding season. *Ibis* 144: 17–22.

Lu, X. and Zheng, G. M. (2003) Reproductive ecology of Tibetan Eared pheasant *Crossoptilon harmani* in scrub environment, with special reference to the effect of food. *Ibis* 145: 657–666.

Manel, S., Ceri Williams, H. and Ormerod, S. J. (2001) Evaluating presence–absence models in ecology: the need to account for prevalence. *J. Appl. Ecol.* 38: 921–931.

McFaden, S. W. and Capen, D. E. (2002) Avian habitat relationships at multiple scales in a New English forest. *Forest Sci.* 48(2): 243–253.

Morrison, M. L., Timossi, I. C. and With, K. A. (1987) Development and testing of linear regression models predicting bird-habitat relationships. *J. Wildl. Manag.* 51: 247–253.

Osborne, P. E. and Tigar, B. J. (1992) Interpreting bird atlas data using logistic models: an example from Lesotho, southern Africa. *J. Appl. Ecol.* 29: 55–62.

Pearce, J. and Ferrier, S. (2000) Evaluating the predictive performance of habitat models developed using logistic regression. *Ecol. Model.* 133: 225–245.

Sather-Blair, C. G. and Liner, R. L. (1980) Pheasant use of South Dakota wetlands during the winter. *Proc. S. D. Acad. Sci.* 59: 147–155.

Turner, S. J., O'Neill, R. V. and Conley, W. (1990) Pattern and scale: statistic for landscape ecology. Pp. 17–51 in M. G. Turner and R. H. Gardner, eds. *Quantitative methods in landscape ecology*. New York: Springer.

Tyre, A. J., Tenhumberg, B., Field, S. A., Niejalke, D., Parris, K. and Possingham, H. P. (2003) Improving precision and reducing bias in biological survey: estimation of false-negative error rates. *Ecol. Appl.* 13(6): 1790–1801.

Wang, S. B. (2003) *Statistical analysis of SPSS*. Beijing: Mechanism Industry Press.

Xu, J. L., Zhang, X. H., Zhang, Z. W. and Zheng, G. M. (2002) Brood habitat characteristics of Reeve's Pheasant *Syrmaticus reevesii* in Dongzhai national nature reserve. *Zool. Res.* 23(6): 471–476.

Young, L., Zheng, G. M. and Zhang, Z. W. (1991) Winter movement and habitat use by Cabot's tragopans in southeastern China. *Ibis* 133: 121–126.

Zheng, G. M. and Wang, Q. S. (1998) *China Red Data Book of Endangered Animals*. Beijing: Science Press.

FEI JIA, NAN WANG and GUANG-MEI ZHENG*

College of Life Sciences, Ministry of Education Key Laboratory for Biodiversity Sciences and Ecological Engineering, Beijing Normal University, Beijing 100875, China.

*Author for correspondence (e-mail: zhenggm@bnu.edu.cn)

Received 29 September 2003; revision accepted 6 December 2004