

Home range and habitat use of Reeves's Pheasant *Syrnaticus reevesii* in the protected areas created from forest farms in the Dabie Mountains, central China

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Summary

Many recently designated or expanded nature reserves in China were forest farms that ceased operations in the aftermath of the catastrophic Yangtze River floods of 1998. Although the vegetation in many of these areas has been altered significantly during forestry operations, there is now an opportunity to reduce, or even reverse, habitat loss for wildlife species that inhabit these forests. One such species is the globally threatened Reeves's Pheasant *Syrnaticus reevesii* that is endemic to the forested mountains of central and south-west China. From April 2000 to August 2003, the habitat use by 14 male Reeves's Pheasants was studied by radio-tracking at Dongzhai National Nature Reserve in the Dabie Mountains, central China. Conifer-broadleaf mixed forest was used preferentially in all seasons at the study area scale, as were mature fir plantations and shrubby vegetation. Moreover, young fir plantations were used preferentially during the breeding season at the scale of the home range. Surveys recorded the pheasant in 13 other protected areas in the Dabie Mountains, and indicated that broadly similar habitat types were available in all of them. Furthermore, Reeves's Pheasant were found in habitats similar to those used preferentially at Dongzhai National Nature Reserve. It seems likely that a mosaic of habitats is crucial to meet the various requirements of male Reeves's Pheasants throughout the year and management should therefore concentrate on maintaining this mosaic. It is now important to identify the habitats that produce the most young pheasants so that nesting and brood-rearing habitats can be clearly identified. Further studies on the habitat mosaic would be useful, both at a local scale and also at a larger, landscape scale.

Introduction

The Chinese government has taken a series of actions to conserve forests in recent years. This includes a ban on logging in the middle and upper reaches of large rivers that was imposed under the National Forest Protection Programme after the Yangtze River floods in 1998 (Liao 1999, BirdLife International 2003). Whilst this logging moratorium was designed to protect the water management function of forests in major river drainages, it also contributed significantly to biodiversity conservation (Hao *et al.* 2000). As a result, forest farms that operated in these areas are no longer charged with timber production and have been designated as protected areas, particularly nature reserves. Among the 1,228 new nature reserves established throughout the country during 1998–2006, 161 are national nature reserves and 303 are provincial reserves, and more than 85% of the new protected areas were created from forest farms (data from the State Forestry Administration database). Now the challenge is to guide management at these former

forest farms so that the habitats present can benefit key elements of native biodiversity. Within China, pheasants and other species in the order Galliformes are both of global biodiversity conservation significance and seem likely to benefit significantly from enhanced forest management (Zhang *et al.* 2003).

Twenty-four per cent of the world's 50 species of pheasant are threatened with extinction (IUCN 2004), making them one of the most threatened groups of birds. China is especially important for the conservation of the world's galliforms, as 55 species have been recorded (Zheng 2005), and 15 of these are considered to be globally threatened (Madge and McGowan 2002, IUCN 2004). Although hunting is perceived to be a significant pressure on pheasants in some areas (Fuller and Garson 2000, McGowan 2002), it is clear that habitat loss and fragmentation are the main threats to their survival (Zhang *et al.* 2003). The establishment and good management of protected areas will provide an opportunity to reduce or even reverse the habitat degradation suffered by many pheasants.

One such species that may benefit from this change in land management is Reeves's Pheasant *Syrnaticus reevesii*, a threatened species that is endemic to China (Cheng 1987). It naturally inhabits broadleaf habitats dominated by oaks *Quercus* spp. in subtropical forests with a dense canopy and sparse undergrowth, at altitudes of 200–2,600 m (Xu *et al.* 1991, Wu *et al.* 1994). The species was widespread and common in central China historically (Cheng *et al.* 1978), but some populations have been extirpated because of illegal hunting, habitat loss and fragmentation (Xu *et al.* 1991, 1995, MacKinnon *et al.* 1996, Zheng and Wang 1998), and the geographical distribution of Reeves's Pheasant in China has been split into two major blocks (Zheng and Wang 1998). Consequently, it is listed on the IUCN Red List as Vulnerable (IUCN 2004), and as a national second-grade protected wildlife species (State Council 1988). Recently, threatened pheasants have been considered to be an important target species-group in the National Wildlife Rescue Program of China, which was officially launched in December 2001 (State Forestry Administration 2001, Zhang *et al.* 2003). Several studies of Reeves's Pheasant have been undertaken in the last decade, including general habitat status (Wu *et al.* 1994), wintering habitat (Fang and Ding 1997, Sun *et al.* 2001, Xu *et al.* 2005, 2006), roost-site (Sun *et al.* 2002), brood habitat (Xu *et al.* 2002), territory (Sun *et al.* 2003), incubation behaviour (Zhang *et al.* 2004) and molecular phylogeny (Zhan and Zhang 2005). However, there is little quantitative information on its habitat requirements, movements and seasonal variation in a managed landscape. Whilst gathering such data on an elusive species is not easy, it is clear that we must adopt an adaptive management approach so that the plantations and other forestry areas can be better managed for conservation in the new protected areas.

We therefore sought to provide information on habitat use of the globally threatened Reeves's Pheasant in nature reserves created from forest farms. Specifically, the objectives were to: (1) assess the home range, the habitat use pattern and its seasonal variation of Reeves's Pheasant in such managed areas; and (2) discuss the management of habitats for Reeves's Pheasant in these protected areas.

Methods

Study site selection and study area

We selected study sites in the Dabie Mountains, as they comprise the major portion of the eastern distribution of Reeves's Pheasant in China (Zheng and Wang 1998). Dongzhai National Nature Reserve (31°40'N, 114°24'E), a former forest farm that is located on the northern slopes of the Dabie Mountain range in Henan province of central China, was selected as our intensive study area. Dongzhai National Nature Reserve was highlighted as one of the 12 most significant Important Bird Areas in the South-east China forest region (BirdLife International 2003) because of its population of Reeves's Pheasant. Fieldwork was carried out from April 2000 to August 2003. An area of 100 km² was designated as Dongzhai provincial nature reserve in 1982

(Song and Qu 1996). This was expanded to 450 km² and upgraded to a national nature reserve in 2001. Much of the additional area was agricultural farmland, shrubby areas and built on, occupying areas of 83 km², 170 km² and 57 km², respectively. The reserve is located in the northern subtropical zone where the natural vegetation is characterized by mature forests dominated by oaks *Quercus* spp., Masson Pine *Pinus massoniana*, Dyetree *Platycarya strobilacea*, Beautiful Sweetgum *Liquidambar formosana* and Hupeh Rosewood *Dalbergia hupeana*. Mature coniferous plantations dominated by Chinese Fir *Cunninghamia lanceolata* occur in the study area. There are also some tea *Camellia* spp. gardens and young plantations of Chinese Fir. Shrubby areas are dominated by young oaks, young Chinese Firs and Glaucous Allspice *Lindera glauca*.

Previous studies have reported that Reeves's Pheasant in this reserve concentrated in the original area, especially in the core areas of this reserve (Song and Qu 1996, Xu *et al.* 2006). Therefore, a 400 ha part of the core area at Baiyun was selected as the main study area (Figure 1). The altitude of this site ranges from 100 m to 446 m, and the climate is warm and humid, with mean annual temperature of 15.1 °C (range 18.2–40.1 °C) and mean annual precipitation of 1,209 mm.

Capture and radio-tracking

Male Reeves's Pheasants were caught using a live decoy during territory establishment during April–May. Nets were placed around the decoy and males were caught as they approached the decoy (Sun *et al.* 2003). This method only works when the males are territorial during the breeding season. Each bird was fitted with a coloured plastic leg ring and a necklace radio transmitter (Biotrack, U.K.), with frequencies between 216.00 and 217.00 MHz. Each transmitter weighed 16 g, less than 2% of the male body weight.

The tagged pheasants were located using a portable TR-4 receiver and a Telonics hand-held antenna. Radiolocations were collected by triangulation from permanent reference points between 05h00 and 19h30 or by direct observations. In most instances (>95%) the distance from observer to pheasant was less than 200 m. All azimuths were collected within a 3 minute period and triangulation angles were between 45° and 135° to reduce telemetry error (Kenward 2001). The time between consecutive radiolocations averaged 12 hours.

Locations were partitioned into four seasons: spring (March–May), which encompassed most mating activity; summer (June–August), when females were rearing broods; autumn (September–November), when young were still associated with their female parent; and winter (December–February), when birds gathered into flocks.

Habitat measurement and analysis

Habitat use was analysed using home range and individual locations. Home ranges were calculated by 95% fixed kernel estimators, which were obtained using a fixed kernel method with least squares cross-validation for the smoothing factor (Worton 1989) available in Animal Movement (Hooge and Eichenlaub 1997), an extension to ArcView GIS 3.2 (Environmental Systems Research Institute 1999). The seasonal home ranges and core areas were estimated for individuals with 30 or more locations in a season, while the annual home ranges and core areas were estimated for ones with 30 or more locations in a year. This number of locations is adequate for fixed kernel home ranges (Seaman *et al.* 1999).

To measure the extent of habitat blocks in the study area, a 1:10,000 vegetation map supplied by the management bureau of the nature reserve was ground-truthed by point observations located 200 m apart throughout the study area. Each point was checked once each season and the plant composition was recorded. This map was digitized to produce a land-cover map of the study site using ArcView GIS 3.2 (Environmental Systems Research Institute 1999). The habitats

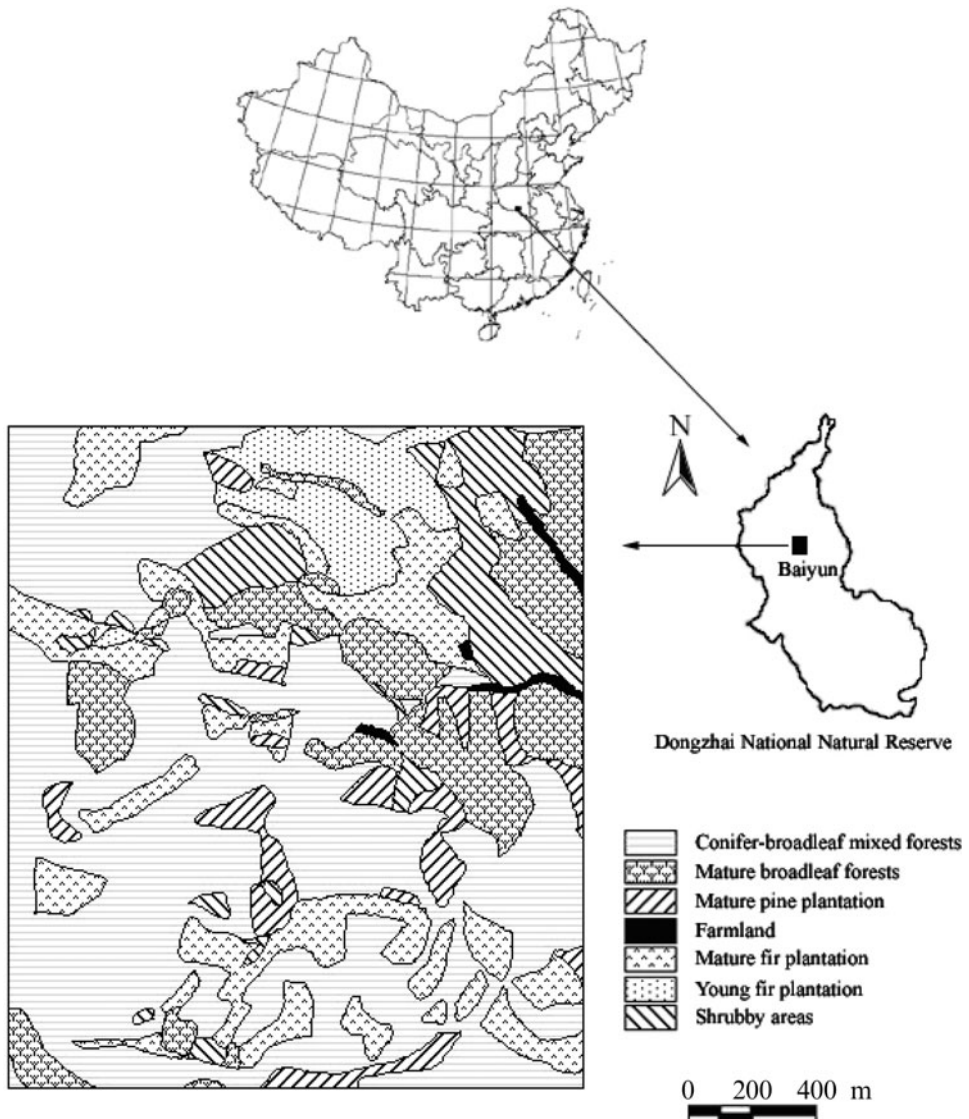


Figure 1. Study site and its habitats in Dongzhai National Nature Reserve, Henan province, central China.

within this site were classified according to plant species present (dominant tree species, such as oak, fir or pine), their composition, and the proportions of the area that they occupied. Overall availability of habitats was quantified by (1) area occupied by a habitat relative to the total area and (2) number of fixed locations present within a habitat relative to the total number of locations for a pheasant.

Habitat use in four seasons by Reeves's Pheasant was evaluated using compositional analysis (Aebischer *et al.* 1993). This method is very informative in analysing location data and it accounts for the extent of each habitat that is actually available (habitat availability was considered as the denominator in the calculation of the log ratios: Aebischer *et al.* 1993). Using

this method, we compared the proportion of each habitat used by an individual with the proportion of that habitat which was available to it at two spatial scales. At a broader scale, we treated habitats within the total available area in the study site as available and those within the home range as used. At a finer scale, we treated habitat within the home range as available and the proportion of the radio-locations within each habitat type as used. Each individual was treated as one sample.

MANOVA was used to determine a Wilk's λ value to evaluate whether differences in log-transformed use and availability proportions differed significantly from zero. Randomization tests were used when the sample size in a season was small (Edgington 1995, Conner *et al.* 2003). In the event of significant non-random habitat use, all possible habitat type pairs were compared by *t*-tests, and the habitat types were then ranked in order of use.

Means are given as mean \pm 1 standard deviation (SD). Randomization was executed by psychStats (<http://www.lcsdg.com/psychStats>) online. Other statistical procedures were carried out using the software SPSS 10.0.1 for Windows (SPSS 1999).

Habitat use by Reeves's Pheasants in other protected areas in the Dabie Mountains

Other protected areas in the Dabie Mountains of central China where Reeves's Pheasant occurred were identified from information obtained by field surveys in 2001 and 2002 (Zhang 2002), interviews with local people, or correspondence with professionals who were familiar with protected areas and with Reeves's Pheasant. Some were surveyed in one season and some in two seasons. We showed pictures of Reeves's Pheasants to the local people, especially the managers of these protected areas, and if they reported that the species occurred, we conducted fieldwork to determine the habitat that the pheasant used. Line transects were distributed randomly in these areas, and all these line transects were surveyed repeatedly in winter or spring. The surveys were conducted from 06h00 to 10h00 and 16h00 to 19h00 in all habitats present at each site.

Results

Habitats in the core area of Dongzhai National Nature Reserve

Seven habitat types were identified in the core area of Dongzhai National Nature Reserve (Figure 1), as follows:

- (1) Conifer-broadleaf mixed forests, dominated by oak, Masson Pine and Chinese Fir comprise 50.0% of the study site. The broadleaf trees occur naturally, but the conifers have been planted. Canopy cover is high in all seasons in this habitat.
- (2) Naturally occurring broadleaf forest, much of which is secondary and was logged 20 years ago. There are also areas where broadleaved trees have been planted, possibly also 20 years ago. Together these account for 14.0% of the study site. The plantation part of the broadleaf forest is dominated by oaks *Quercus* spp. that were planted for various uses, most notably the production of acorns which are an important economic crop. This habitat has a dense canopy in spring and summer, but becomes sparse in autumn, and especially in winter. Some parts of this habitat were subject to significant human activity.
- (3) Mature pine plantation dominated by Masson Pine trees that are at least 20 years old account for 6.0% of the study site; it has a sparse undergrowth and a dense canopy throughout the year.
- (4) Mature Chinese Fir plantation dominated by trees that are at least 20 years old accounts for 16.1% of the study site; it also has a sparse undergrowth and a dense canopy throughout the year.
- (5) Young Chinese Fir plantation that is less than 5 years old and with trees <2 m tall occupies 5.6% of the study site.

- (6) Shrubby vegetation <3 m in height and which is the result of natural regeneration within the last 5 years accounts for 7.8% of the study area. These areas contain *Lindera glauca*, *Rosa cuimosa*, *Lespedeza* spp. and *Vitex negundo*.
- (7) Farmland occupies only 0.6% of the study site, is mostly situated at the edge of the site and is subject to severe human impact throughout the year.

Habitat use and seasonal variation

Seventeen male Reeves’s Pheasants were captured and radio-tagged between 2000 and 2002 (9, 5 and 3 individuals in April 2000, 2001 and 2002, respectively). Altogether 1,694 radio-locations were recorded. The sample sizes in spring, summer, autumn, winter were 12, 10, 6 and 5 individuals, respectively. The home range of males ranged from 9.5 to 23.9 ha.

At the broader scale of home range establishment within the study site, male Reeves’s Pheasant were selecting particular habitats throughout the year (Table 1). Mixed forests were used more than they were available ($t_{11} = 4.455, P < 0.001$) in spring; pine forests were used less than available ($t_9 = -2.964, P = 0.016$) in summer; and young plantation was used less than available in autumn and winter (autumn: $t_5 = -2.908, P = 0.033$; winter: $t_4 = -2.918, P = 0.043$). In addition, farmland was used less than available ($P < 0.05$) in all seasons. In general the pattern of habitat use was similar throughout the year (Table 1), especially in spring and summer. Mixed forest, mature fir plantation and shrubby areas were used significantly more than young plantation and farmland in all four seasons ($P < 0.05$). In spring and summer, mixed forest and mature fir plantation were used more than other habitat types ($P < 0.05$) except for broadleaf forest.

At the finer scale of habitat use within the home range, male Reeves’s Pheasants used habitats non-randomly in spring and summer when comparing habitats used and those available in the home range (Table 1). Mixed forests were used more than available in summer ($t_9 = -2.323, P = 0.045$), as was young plantation ($t_9 = 3.662, P < 0.005$), whereas shrubby areas were used less than available in spring and summer (spring: $t_{11} = 2.061, P = 0.044$; summer: $t_9 = -3.032, P = 0.014$). Overall, mixed forest and young plantation were used more than other habitats ($P < 0.05$) and young plantations were used more than mixed forest, mature fir plantation and shrubby vegetation ($P < 0.05$).

Table 1. Seasonal habitat rankings from compositional analysis of habitat use by male Reeves’s Pheasant in central China.

Order	Season	Males	Wilk’s Λ	df	F	Ranking of habitats ^a
Home range vs study area	Spring	12	0.038	6, 17	71**	Mixed = Fir > Shrub > Broadleaf > Pine > Young plantation > Farmland
	Summer	10	0.003	6, 13	715**	Mixed = Fir > Shrub > Broadleaf > Pine > Young plantation > Farmland
	Autumn	6	0.001	5, 6	2150*	Fir > Mixed > Shrub > Broadleaf > Pine > Farmland > Young plantation
	Winter	5	0.013	4, 5	94*	Shrub > Mixed > Fir > Broadleaf > Pine > Farmland > Young plantation
Fixed locations vs home range	Spring	12	0.210	5, 14	11*	Mixed > Young plantation > Fir > Pine > Broadleaf > Shrub
	Summer	10	0.201	6, 13	9**	Young plantation > Mixed > Fir > Broadleaf > Pine > Shrub
	Autumn	6	0.044	5, 6	26 ^{ns}	–
	Winter	5	0.407	4, 5	2 ^{ns}	–

* $P < 0.05$; ** $P < 0.01$; ns, not significant.

^aRanks represent the importance of each habitat in descending order from most to least important.

Habitat used by Reeves's Pheasants in other protected areas in the Dabie Mountains of central China

Reeves's Pheasant occurs in 13 other protected areas in the Dabie Mountains spanning three provinces: Anhui, Henan and Hubei (Table 2). The reserves were established for various reasons, with some reserves created specifically for the conservation of Reeves's Pheasant, such as Dongzhai National Nature Reserve while other reserves were established primarily for protecting the forest ecosystem. Eleven of the protected areas were forest farms before they became protected areas and, therefore, a considerable proportion of each has a history of logging and replanting.

The habitat types in these protected areas were similar to each other, comprising conifer-broadleaf forests, mature broadleaf forests, mature fir plantation, shrubby vegetation, pine plantation, young fir plantation and farmland. Only three protected areas held some secondary broadleaf forests, i.e. Tianma, Jigongshan and Liankangshan. However, the landscape mosaic of habitats in these protected areas was very different from each other. For example, the proportion of pine plantation in Zhonghuashan was >80%, but that in Lianhuashan was <20%.

Reeves's Pheasant in these protected areas used conifer-broadleaf mixed forest, mature fir plantation, shrubby vegetation or pine plantation in spring and winter (Table 2), but there were no Reeves's Pheasants recorded in broadleaf forest in winter, or in secondary broadleaf forests in two seasons (Zhang 2002).

Discussion

Assessments of habitat use of threatened species in former forest farms that are now protected areas in China are needed if management is to be designed to benefit them as much as possible. However, conducting such studies is often difficult because of low encounter rates, relatively low densities and difficult terrain over which to conduct fieldwork. The extent of the challenge is considerable given the number of threatened species, such as Reeves's Pheasant, that are likely to be present in China's new protected areas. Therefore, we advocate an adaptive management

Table 2. Protected areas that contain Reeves's Pheasant in the Dabie Mountains of central China.

Name	Level of nature reserve	Size (ha)	Province	Habitats used	Survey methods ^a
Tianma ^d	National	28,914	Anhui	Fir, mixed, pine, shrub	LT and ILP
Yaoluoping	National	12,300	Anhui	Mixed, fir, pine	LT and ILP
Bancang ^c	Provincial	5,000	Anhui	Fir, pine, shrub	CP
Wanfoshan ^c	Provincial	1,523	Anhui	Fir, shrub, pine	CP
Kujingyuan ^c	Provincial	2,000	Anhui	Fir, pine, shrub	CP
Jigongshan ^{c,d}	National	2,917	Henan	Fir, mixed, shrub, mature broadleaf, pine	CP
Dongzhai ^{c,d}	National	46,800	Henan	Mixed, fir, shrub, broadleaf, pine	LT
Liankang Shan ^{c,d}	National	10,580	Henan	Fir, pine, mixed, mature broadleaf,	LP
Jingangtai ^d	Provincial	2,972	Henan	Fir, pine, shrub	LP
Taibaiding ^c	Provincial	4,924	Henan	Fir, pine, shrub	CP
Tianmushan ^c	Provincial	6,750	Henan	Fir, pine, shrub	CP
Huangbaishan ^{b,d}	Forest Park	2,100	Henan	Fir, shrub	LT
Zhonghua Shan ^{b,c,d}	Forest Park	6,927	Hubei	Fir, pine, shrub	LT
Dabieshan ^c	Provincial	44,011	Hubei	Fir, pine, shrub	LT

^aLT, line transects; ILP, interview with local people; CP, correspondence with professionals.

^bForest Park, i.e. an area where tourism is primary, and conservation is secondary.

^cThe sites were investigated in winter.

^dThe sites were surveyed in spring.

approach (see Walters 1986, Salafsky *et al.* 2001, 2002) to enhance the value of these reserves for target species so that all current biological information is used in management whilst at the same time key knowledge gaps are filled with additional research. Therefore, we discuss the observed habitat use both within the reserve and elsewhere in the Dabie Mountains before drawing these management and research conclusions.

Habitat use

Male Reeves's Pheasants showed a significant preference for conifer-broadleaf forest, mature fir plantations and shrubby patches, compared with farmland and young fir plantations. The conifer-broadleaf forest seems likely to provide both good cover and food throughout the year (Sun 2001). The shrubby vegetation also probably provides good cover and many acorns, which in turn may provide plenty of food (Xu *et al.* 1991, Song and Qu 1996, Sun 2001, Xu 2004). Mature fir plantations were preferred significantly by the pheasants throughout the year and especially in autumn. Again, this is probably due to the provision of good cover and larger trees for roosting (Sun *et al.* 2001).

Although there was no significant preference for mature broadleaf forest, this forest type does offer some resources to the species. For example, it provides food and some nest-sites for females (Sun 2001) as well as roost-sites in spring and summer (Sun *et al.* 2002), as was the probably the case in this study. Many of the oak trees throughout a large proportion of the broadleaf forest produced acorns in sufficient quantity to make them one of the major agricultural products for people in this area. To make collection easier, they clear the undergrowth so that acorns can be seen on the ground more easily. Consequently, there was considerable human disturbance to Reeves's Pheasants in the autumn. In addition, the canopy of this habitat was sparse in spring and winter, which may lead to an increase in predation by raptors in this area (Xu *et al.* 2002).

It has been suggested that farmland might provide supplementary food for Reeves's Pheasants in some places, especially in winter (Xu *et al.* 1991, Wu *et al.* 1994). However, farmland was not an important habitat for the species in Dongzhai National Nature Reserve. Although some non-tracked individuals were occasionally observed foraging in farmland near the forest edge in all four seasons, no radio-tagged individuals were observed in this habitat, which might imply that there was sufficient food within their home ranges, or that a lack of cover made them susceptible to predation.

Some individual birds that used young fir plantation within their home range showed a strong preference for this habitat. Sun (2001) stated that young plantations were the preferred nesting habitat of females, and so perhaps males used this habitat preferentially to increase the number of encounters with females.

Other reserves with Reeves's Pheasant in the Dabie Mountains of central China

A number of key locations for the species have now been turned into protected areas in this part of the range, but previous human exploitation may have led to some differences in the habitat mosaic between sites. Overall, forestry development and the expansion of agriculture have resulted in increased proportions of mature fir plantation and shrubby vegetation in these former forest farms.

Overall, the extent of natural broadleaf forest and conifer-broadleaf mixed forest has declined markedly as a result of logging activities (Xu *et al.* 1991, MacKinnon *et al.* 1996, Fuller and Garson 2000, BirdLife International 2001), and the proportion of mature fir plantation and shrubby vegetation has increased because of replanting after initial felling of natural forest stands. Indeed, mature fir plantations have become the most extensive habitat type in some protected areas, such as Jingangtai, Taibaiding and Liankangshan Nature Reserves. Field surveys revealed that mature fir plantations, shrubby vegetation and conifer-broadleaf mixed forest were

used by Reeves's Pheasant in these reserves (Zhang 2002). Overall, the habitat types available and their use by Reeves's Pheasant in other protected areas appear broadly similar to that in Dongzhai National Nature Reserve. Therefore, it is possible that the conclusions drawn from this study at Dongzhai National Nature Reserve may be highly relevant to other protected areas.

Adaptive management implications

Although this study has not provided unequivocal information that can be used to produce a detailed habitat management prescription for Reeves's Pheasant in the reserves of the Dabie Mountains, it provides clear pointers that should be acted upon adaptively. Deciduous broadleaf forest containing conifer trees seems to have been the original habitat in the Dabie Mountains (Song and Qu 1996), but much forest was destroyed in the mid-1950s (BirdLife International 2003) and has been replaced with conifer-broadleaf mixed forest. Now, conifer-broadleaf mixed forest is the most extensive cover type in central China (Hou 2001). It was preferred significantly by male Reeves's Pheasant in Dongzhai National Nature Reserve and, therefore, maintaining this semi-natural habitat is likely to be critical for the survival of this species in the short to medium term. In recent decades, mature fir plantations have become a major part of the habitat mosaic in this landscape and male Reeves's Pheasants, at least, use this habitat. Shrubby vegetation was used preferentially by radio-tagged males, and the individuals in shrubby vegetation did not move far from forest (Xu *et al.* 2005) presumably because the bigger conifer trees were used for roosting (Sun *et al.* 2002). Thus, it is reasonable to assume that the proximity of forest and shrubby vegetation is a critical factor influencing habitat use by Reeves's Pheasants. Consequently, habitat management should aim to maintain the mosaic of habitats that exists, ensuring especially that there are sufficient patches of conifer-broadleaf mixed forest, young and mature fir plantation, and shrubby areas close to tall forest. If extensive areas of the original broadleaf forest become established in the future it will be important to evaluate how the species uses the habitats that are then present.

Young fir plantations were important for male Reeves's Pheasant in the breeding season and Sun (2001) states that females nest in this habitat. Therefore, maintaining suitable nesting habitat, which appears to be a relatively early successional stage in forest development, is crucial for the long-term conservation of this species. However, young plantations were subject to management in June and July each year when grass and other vegetation growing around saplings was removed, and this may interfere with the breeding activities of Reeves's Pheasant which may nest until June (Zhang *et al.* 2004). Therefore, it seems appropriate that routine annual management in young plantation should be carried out a little later so as to minimize negative impacts on the species' reproductive output.

There seem to be two key research areas arising from this study. The first is finding out which habitat types are most important for recruitment into the adult population, i.e. the best nesting and brood-rearing habitats. Although it can be inferred from this study that young fir plantations are used by nesting females, it is vital to confirm that successful nesting attempts are made in this habitat. Assumptions that the similarly threatened Swamp Francolin *Francolinus gularis* from India and Nepal bred successfully in sugar-cane plantations because many males were heard calling from that artificial habitat proved incorrect when radio-tracking revealed that the only successful nests were those in grassland or fallow farmland (Iqbal *et al.* 2003). The same study should also determine which brood-rearing habitats are crucial for the species and ensure that food availability is sufficient at this critical stage. The second research requirement is for a more thorough knowledge of the size and local proximity of habitat patches so that the species' needs can be met throughout the annual cycle. This should be contrasted with a larger scale landscape analysis of habitat use that includes assessing the dispersal of young birds and the connectedness of neighbouring populations.

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