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Source: Wildlife Biology, 9(4) : 371-375

Published By: Nordic Board for Wildlife Research

URL: <https://doi.org/10.2981/wlb.2003.027>

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Occurrence of hazel grouse *Bonasa bonasia* in a heavily human-impacted landscape near the Changbai Mountains, northeastern China

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Sun, Y-H., Piao, Z-J. & Swenson, J.E. 2003: Occurrence of hazel grouse *Bonasa bonasia* in a heavily human-impacted landscape near the Changbai Mountains, northeastern China. - Wildl. Biol. 9: 371-375.

The occurrence of hazel grouse *Bonasa bonasia* in forest patches in a heavily human-impacted landscape with a matrix dominated by agricultural fields in northeastern China was documented four times during autumn and spring 2000-2002. The occurrence of hazel grouse in fragmented landscapes in Europe is influenced by patch isolation, size and composition. In China, we found that patch composition and size, and their interaction, best explained the pattern of hazel grouse occurrence, with a greater probability that grouse were found in larger patches with more deciduous trees. In contrast to results from Europe, isolation distance was not an important explanatory variable. In addition, hazel grouse in China used patches with a higher deciduous component. Thus, although still vulnerable to habitat fragmentation, Asian hazel grouse seem to be less vulnerable than European hazel grouse. One reason may be that Asian hazel grouse are adapted to more open, deciduous-dominated habitats and form flocks in winter, which may allow them to move more freely over open habitats to forest patches. Continued habitat fragmentation and the planting of small forest patches to coniferous-dominated forest are detrimental to hazel grouse in the study area. Future plantings should contain more deciduous trees and consideration to the landscape effects reported here should be given.

Key words: *Bonasa bonasia*, hazel grouse, landscape ecology, habitat requirements, People's Republic of China

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Human-caused changes to, destruction of, and reduction of sizes of natural habitats, combined with increasing distances between the remnant habitats, are important causes of the decline in biological diversity in boreal forests (DeGraaf & Miller 1996). Andrén (1994) has shown that negative effects of fragmentation on bird and mammal species, beyond that of habitat loss alone, be-

come more apparent when the amount of habitat in a landscape declines below a threshold of about 30%. Rolstad & Wegge (1989) proposed a similar threshold for capercaillie *Tetrao urogallus*. Beyond the effects of fragmentation *per se* are the effects of the types of matrix in the landscape. Matrix can be defined as the dominating element in a landscape that surrounds the

habitat suitable for the species (Stamps, Buechner & Krishnan 1987), and can be a very important factor influencing the pattern and dynamics of populations in fragmented landscapes (Forman & Godron 1986). The quality and quantity of the matrix influences the colonization rates of habitat islands within the matrix (Gascon, Lovejoy, Bierregard, Malcolm, Stouffer, Vasconcelos, Laurence, Zimmerman, Toucher & Borges 1999), with edges of moderate contrast being more permeable (Wiens 1990).

The hazel grouse *Bonasa bonasia* has been shown to be very reluctant to enter open areas outside Norway spruce *Picea abies* forests in Europe (Swenson 1993a, b). Consistent with this, it has also been found to be highly susceptible to the fragmentation of suitable habitats, with short distances of isolation leading to the absence of hazel grouse in suitable habitats (Åberg, Jansson, Swenson & Angelstam 1995, Saari, Åberg & Swenson 1998, Åberg, Swenson & Andrén 2000b). The hazel grouse appears to be more sensitive to the quality of the matrix for dispersal within fragmented landscapes than is expected for birds, and open, agricultural land is a more difficult matrix to cross than unsuitable, but forested, habitats (Åberg et al. 1995). This phenomenon seems to be general in Europe, as it has been documented at three sites in Sweden (Åberg et al. 1995, Åberg et al. 2000b, Åberg 2000), in Finland (Saari et al. 1998), and in the Czech Republic (Sewitz 1997).

The effects of forest fragmentation on hazel grouse have not been investigated in Asia. There is reason to suspect that hazel grouse might be less affected in Asia because of differences in winter behaviour. In Europe, hazel grouse overwinter almost exclusively as singles or pairs. They stay in dense forest habitats and only venture a few meters from the edge of such habitats to forage (Swenson 1993a). In many parts of Asia, however, hazel grouse use much more open habitats, often dominated by deciduous forest or in pure deciduous forests, perhaps because they form flocks that allow better defense against predation than singles and pairs (Swenson, Andreev & Drovetskii 1995). Hazel grouse also form flocks in winter in the Changbai Mountains (Sun & Fang 1997). In addition, hazel grouse seem to be able to disperse relatively long distances in Asia, perhaps longer than in Europe (Fang & Sun 1997).

In the studied landscape in northeastern China, originally mixed forests, dominated by deciduous trees, are being fragmented to provide more agricultural fields. In addition, after cutting, areas that are to remain as forests are being replanted as pure coniferous forests, especially with *Pinus koraiensis*, *P. sylvestris*, and *Larix olgensis*. It is well documented that hazel grouse on both conti-

nents depend upon the buds and catkins of certain deciduous trees for winter food, and hazel grouse are generally not found in pure coniferous forest (Swenson 1993b, Swenson & Angelstam 1993, Yang 1993, Swenson et al. 1995, Bergmann, Klaus, Müller, Scherzinger, Swenson & Wiesner 1996), and especially not in pine-dominated forests (Lindén & Wikman 1983, Åberg, Jansson, Swenson & Mikusinski 2000a, Åberg, Swenson & Angelstam 2003). The purpose of this study was to investigate the effects of this human use of the landscape on the occurrence of hazel grouse.

Study area

The studied landscape is an area of about 3 x 5 km located in the Xiao Sha He and Song Jiang townships on the northern slope of the Changbai Mountain, Jinlin Province in northeastern China (42° 35'–42° 39' N, 128° 15'–128° 24' E). The landscape is gently rolling, with altitudes varying between 600 and 800 m a.s.l. The climate is cool and influenced by monsoons. The annual mean temperature is 3.3°C, the annual precipitation averages 673 mm, and the frost-free period is 100–150 days.

The landscape is dominated by croplands for the production of ginseng *Panax ginseng*, other medicinal herbs such as *Adenophora* sp., and cereal crops, although villages also occupy some of the area. Forest patches comprises about 26% of the landscape. Hedgerows of shrubs, up to 2 m tall and 2 m wide, connect some patches. The most common trees in the deciduous-dominated forest patches are *Quercus mongolica*, *Betula platyphylla*, *Populus davidiana*, *Ulmus* spp., *Padus asiatica*, *Malus baccata*, *Salix* spp., and *Crataegus* spp. Common shrubs include *Corylus mandshurica*, *Evonymus* spp., *Lonicera* spp., *Salix* spp., and *Lespedeza* spp. The distance from the studied landscape to the nearest continuous mixed forest that is inhabited by hazel grouse is at least 5 km.

Before the 1960s, natural deciduous-dominated forest comprised about 69% of the studied landscape. The population of farmers in the 1960s consisted of several hundred families, but has now grown to more than 2,000 families. During the past 10 years, the planting of ginseng has grown dramatically, at about 5% per year. Now, half of the deciduous-dominated forest area present 10 years ago has been converted to ginseng farms. In addition, local people use wood for winter heating, with each family cutting about 100 m² of shrubs and deciduous trees for their annual needs. After 40 years of forest cutting and planting to conifers, about 93% of the remaining forest is planted and conifer-dominated.

During the last five years, the authorities have collected all guns and forbidden hunting in the area. Consequently, hazel grouse are not hunted any longer, although previously, the hunting pressure on hazel grouse was high (Zhang 1985).

Methods

All potentially suitable forest patches in the landscape were censused for the presence of hazel grouse. Most islands less than 3 ha in size were not censused, as this lies below the size of a hazel grouse spring home range in the Changbai area (Sun, Swenson & Fang 2000).

We conducted censuses in a manner similar to that described by Swenson (1991). A Scandinavian hunter’s whistle was also used to imitate the hazel grouse territorial song, but whistling was conducted at 100-m intervals and for five minutes, rather than at the 150-m intervals and for six minutes as recommended by Swenson (1991). Thus, we probably conducted a more thorough census than Swenson’s (1991) method, which detected > 82% of the territorial males present. Censuses were conducted four times in each patch: in spring (March and April) 2001 and 2002 and in autumn (September and October) 2000 and 2001.

The size of forest patches were obtained from a forestry map (scale 1:25,000) prepared by the local forestry authorities. The distance from each patch to the nearest patch that had been occupied by hazel grouse sometime during the study was measured to the nearest 10 m using the map. The proportion of deciduous trees in the forest patches was estimated into five categories within 100 m² (10 x 10 m) quadrates. The quadrates were randomly located within the forest patches, with one in the smallest and up to five recorded in the largest patches.

Table 1. Model of the occurrence of hazel grouse in a fragmented landscape in northeastern China, based on a generalized linear model.

Source	Coefficient estimate	SE	z value	P
Intercept	-2.551	0.587	4.344	0.00001
Conifer	0.5104	0.178	2.859	0.004
Patch size	0.046	0.020	2.263	0.024
Distance	-0.002	0.002	0.850	0.395
Conifer*Patch size	-0.011	0.0051	2.244	0.025
Patch size*Distance	0.00001	0.00001	1.048	0.295
Conifer*Distance	0.0002	0.0008	0.262	0.793

From the four censuses, an index of hazel grouse occurrence was obtained, varying from 0 (never found) to 1.0 (found in all four censuses). Because this index was not normally distributed, we conducted the analysis using a generalized linear model. Independent variables entered were patch size and linear distance to the nearest patch where hazel grouse were observed at least once during the study, the proportion of deciduous trees in the patch (entered in categories), and the two-way interactions of these variables were also included in the model. The model was run in the program R, version 1.5.1., R Development Core Team. The probit link function was selected, based on the Akaike Information Criterion, although the other link functions gave similar results.

Results

A total of 66 forest patches, including all ≥ 3 ha in size and some even smaller, were censused four times in the landscape during the study period. The patches varied in size from 2.3 to 450 ha and the distance to the nearest patch where hazel grouse were observed at least once during the study varied from 30 to 1,000 m. Hazel grouse were observed in patches 36 times, or 14% of

Table 2. Relationship between patch size, proportion of deciduous trees in the patch and proportion of the censuses with hazel grouse in a fragmented landscape in northeastern China. Sample sizes are given in parentheses.

Patch size (ha)	Proportion of deciduous trees in the patch (%)					Mean
	0	1-19	20-39	40-59	60-75	
2- 9	0.01 (29)		0 (1)	0.50 (1)		0.02 (31)
10-19	0.03 (8)	0.05 (5)	0 (1)			0.04 (14)
20-39	0.12 (2)	0.25 (1)	0.19 (4)	0.25 (4)	0.12 (2)	0.17 (13)
40-60			0.25 (1)	0.50 (1)		0.38 (2)
≥100				0.85 (5)	0.25 (1)	0.75 (6)
Mean	0.02 (39)	0.08 (6)	0.14 (7)	0.52 (11)	0.17 (3)	0.14 (66)

Patch size (ha)	Proportion of deciduous trees in the patch (%)					Mean
	25-40	41-60	61-80	81-99	100	
2- 9			0 (1)		0.01 (29)	0.02 (31)
10-19			0 (1)	0.05 (5)	0.03 (8)	0.04 (14)
20-39			0.19 (4)	0.25 (1)	0.12 (2)	0.17 (13)
40-60			0.25 (1)			0.38 (2)
≥100						0.75 (6)
Mean			0.14 (7)	0.08 (6)	0.02 (39)	0.14 (66)

the 264 patch censuses (66 patches x 4 seasons). A total of 76 hazel grouse (46 males, 22 females and eight of unknown sex) were detected during the censuses, which gave an overall average minimum density of 0.86 hazel grouse per 100 ha forest per season on the 2,211 ha of forest patches ≥ 3 ha in size within the 15 km² landscape, or about 0.58 males per 100 ha.

The analysis provided a highly significant model (Table 1). The most important factors identified were the proportion of deciduous trees ($P = 0.0004$), patch size ($P = 0.024$) and the interaction deciduous*patch size ($P = 0.025$, see Table 1). The interaction between the proportion of deciduous trees and patch size was complicated, as patches of small size and a low proportion of deciduous trees had the lowest probability of containing hazel grouse; most of the smallest patches had 0% deciduous trees (Table 2).

Hazel grouse were most commonly found in patches larger than 20 ha in size, containing 40-59% deciduous trees (see Table 2), and all were found within 370 m from the nearest occupied patch.

Discussion

We found that the composition and size of forest patches, and their interaction, best explained the occurrence of hazel grouse in a highly fragmented landscape in China with agricultural land as the matrix. The probability of hazel grouse occurrence increased as the proportion of deciduous trees in a patch and the size of a patch increased. However, isolation of the patches was not an important explanatory variable.

There seems to be some basic differences between China and Europe in the effects of landscape variables on hazel grouse. Isolation has been documented to be a very important variable explaining hazel grouse occurrence in several landscapes in Europe (Åberg et al. 1995, 2000b, Sewitz 1997, Saari et al. 1998). Isolation is most dramatic when the matrix is agricultural land, with a threshold of only about 100 m in Sweden (Åberg et al. 1995) and 240 m in the Czech Republic (Sewitz 1997), compared with the 370 m we found in China. The effect of isolation may have been ameliorated in China by the presence of shrubby hedgerows, which could serve to connect the patches within the agricultural matrix. This is supported by the results from Europe, because hedgerows did not exist in the Swedish study area (Åberg et al. 1995, J.E. Swenson, pers. obs.), but they were present in the agricultural matrix in the Czech Republic (Sewitz 1997). However, Åberg et al. (1995) measured the distance from habitat islands to suitable hazel grouse

habitat, not occupied habitat, as we did. This difference in methods may reduce the comparability of the results. In Scandinavian boreal forests, hazel grouse are most common in forests with 5-40% deciduous trees (Swenson & Angelstam 1993, Åberg et al. 2003). The Chinese hazel grouse seemed to prefer a higher proportion of deciduous trees in the forest patches (40-59%), but showed a similar size threshold (ca 20 ha) to those in Europe, i.e. 10 ha in Sweden and Finland (Åberg 2000, Åberg et al. 2000b, Saari et al. 1998) and 20 ha in the Czech Republic (Sewitz 1997).

We conclude that hazel grouse in Asia is also sensitive to habitat fragmentation, as has been documented for the species in Europe. However, they seem to be less sensitive to patch isolation than European hazel grouse, perhaps because they are adapted to more open deciduous forests than European hazel grouse and have behavioral adaptations to facilitate movement in more open habitats, such as winter flocking (Swenson et al. 1995).

The overall average minimum density in the forest in our study area was 0.86 hazel grouse per 100 ha. This was considerably less than the 2.8 hazel grouse per 100 ha found in a nearby continuous forest in a natural reserve during 1986-1995 (Piao & Sun 1997). Although the census methods differed, the difference probably reflects the effects of habitat fragmentation, both small size of most patches and isolation effects, and the unfavourable forest composition in many patches.

Recommendations

It is obvious that the transformation of the mixed forest to small and purely coniferous forest patches is detrimental to hazel grouse and is probably contributing to a decline in the species in the studied landscape. As these forests are state-owned lands and the local forest authorities are responsible for replanting cut forest, we recommend that they adopt a requirement that at least 40% deciduous trees be planted when cut areas are replanted. Hazel grouse in the area eat a wide range of deciduous buds and catkins in the winter, but the most important species are *Acer mono*, *Populus davidiana*, *Corylus mandshurica*, *Betula platyphylla*, and *Salix raddeana* (Yang 1993). These species should be given priority in the replanting of cut areas.

Acknowledgements - the field work was financed by funds from the Changbaishan Research Station on the Forest Ecosystem and the Chinese Academy of Sciences (grant no. CBS99-06). The National Natural Science Foundation of China, the Norwegian Research Council and the Agricultural University of Norway funded J.E. Swenson's cooperation.

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