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Characteristics of hazel grouse *Bonasa bonasia* distribution in southern Korea

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During October 1998 - May 1999, we studied the distribution of hazel grouse *Bonasa bonasia* and the structure of their habitats in southern Korea. Hazel grouse were censused from the responses to calls imitated using a Scandinavian metal hunter's whistle in winter and spring along line transects. Hazel grouse were distributed in most of the high mountain forest areas in southern Korea. The frequency of occurrence varied with altitude within the range of 300-1,200 m a.s.l., with the highest density at 600-900 m a.s.l. Altitudinal distribution differed between seasons, however, and hazel grouse were observed at lower altitudes more often in winter than in spring. They occurred in mixed, deciduous and coniferous forest areas, but the use of forest types varied by season. Particularly many individuals were observed in planted Japanese larch *Larix leptolepis* forests. The coverage and density of understory vegetation was more developed where hazel grouse were observed, but coverage more than 2 m above ground did not seem to be important in explaining hazel grouse presence. The occurrence of hazel grouse was related to the development of understory vegetation more than to forest type. Seasonal use of forest types may have been related to the combined availability of food and cover in understory vegetation.

Key words: Bonasa bonasia, distribution, habitat structure, hazel grouse, southern Korea

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The hazel grouse *Bonasa bonasia* is distributed over northern and central Eurasia (Vaurie 1965). The species requires fairly large forests with rich undergrowth, variable forest density, a variety of plant species and occasional clearings. At least in Europe, it requires a certain proportion of deciduous trees within the coniferous forests and avoids pure coniferous forests (Swenson & Angelstam 1993). Conifers, although used for concealment and nocturnal roosting, do not seem to be essential, as the hazel grouse also occurs in areas lacking evergreen conifers in Europe (Glutz von Blotzheim 1973, Beshkarey, Blagovidov, Teplov & Hjeljord 1995). The hazel grouse is extinct or declining over a large portion of its range in Europe (Swenson & Danielsen 1991). Censuses on the Island of Hokkaido in Japan, have also indicated a general decline there (Fujimaki 2000).

The southernmost edge of the hazel grouse distribution in Asia is the Korean Peninsula. However, the distribution range of hazel grouse is still unclear (Johnsgard 1983, Koo & Lee 1990, Han & Fujimaki 1996). The hazel grouse was first recorded on the Korean Peninsula by Tyaczanowski in 1885. Since then a number of studies have described capture or sight records from various areas of the Korean Peninsula (Han & Fujimaki 1996). Nevertheless, the distribution of and the

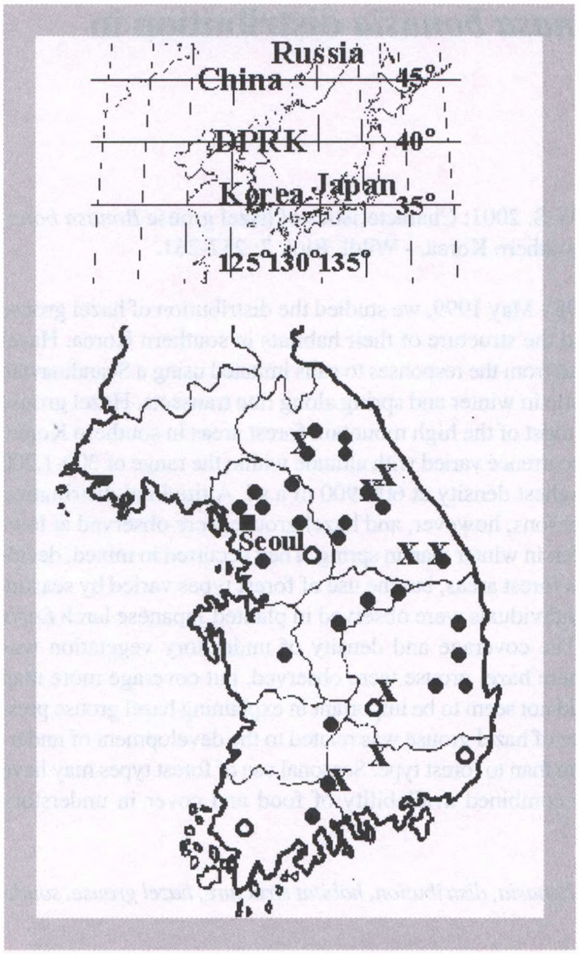

Figure 1. Distribution of hazel grouse in southern Korea. ● indicates location of hazel grouse; ○ indicates site where hazel grouse were not found; X indicates locations where hazel grouse have been found previously. Sources: Johnsgard (1983), Koo & Lee (1990) and Han & Fujimaki (1996).

habitat used by hazel grouse on the Korean Peninsula are poorly known.

We studied the seasonal distribution of hazel grouse and habitat structure to document the characteristics of habitat for their proper protection management in southern Korea. In addition, we have obtained an index of abundance which can be used to monitor future trends in the population.

Methods

Our study was conducted in the 30 major mountain forest areas throughout southern Korea (Fig. 1). In the 30 mountain areas, we selected 45 study sites consisting of potential habitats for hazel grouse. The 45 study sites represented the major forest types in southern Korea, i.e. deciduous, coniferous and mixed forests. They varied in altitude within 300-1,200 m a.s.l. The timber line is above 1,300 m a.s.l. in our study areas. In deciduous forests the dominant tree species were Mongolian oak *Quercus mongolica*, oak *Q. serrata*, Japanese elm *Ulmus davidiana*, and Korean ash *Fraxinus rhynchophylla*, in coniferous forests, pitch pine *Pinus rigida*, Japanese red pine *P. densiflora*, Korean pine *P. koraiensis*, and Japanese larch *Larix leptolepis*, in mixed forests Japanese larch, pitch pine, giant dogwood *Cornus controversa*, and cork oak *Q. variabilis* in mixed forests (Ministry of Environment 1995).

Two-kilometre long transects were placed in each study site, were selected to represent the forest types in the study areas, and ran from the bottom to the summit of the mountains.

Hazel grouse were censused twice along each transect, in winter (snow season, i.e. December and January) and in spring (snow-free season, i.e. April and May). The census was conducted using a Scandinavian metal hunter's whistle. When using this method, an observer walks as quietly as possible to census points located at 150 m intervals along the transect to be counted. At the census points the observer blows his whistle for six minutes, repeating the song about every 30 seconds. After six minutes, the observer moves on to the next point. The method used in our study was developed and tested on radio-collared birds by Swenson (1991a), and it detects about 82% of all territorial males.

The habitat structure was described within an imaginary cylinder with a diameter of five metres at each hazel grouse observation and non-observation point according to Lee (1996). The non-observation points were randomly selected along the transects used for the survey of the habitat structure. Foliage height was classified into seven layers, i.e. >20 m, 16-20 m, 12-

Table 1. Relative density of hazel grouse in southern Korea according to elevation and season (winter and spring). The numbers of hazel grouse observed per kilometre of transect are given in parentheses for each altitudinal zone.

	Elevation above sea level (x 100 m)										
Season	3	4	5	6	7	8	9	10	11	12	Total
Winter	0.7 (6/9)	1.7 (15/9)	1.8 (16/9)	2.9 (26/9)	2.2 (20/9)	0.8 (7/9)	0.4 (4/9)	0.2 (2/9)	1.2 (2/9)	0.1 (1/9)	1.1 (99/90)
Spring	0 (0/9)	0.1 (1/9)	0.8 (7/9)	1.3 (12/9)	1.9 (17/9)	2.3 (21/9)	2.3 (21/9)	1.3 (12/9)	1.8 (16/9)	0.4 (4/9)	1.2 (111/90)

Table 2. Relative density of hazel grouse in different forest types in southern Korea according to season (winter and spring). The numbers of hazel grouse observed per kilometre of transect are give in parentheses for each habitat type.

Habitat type	Winter	Spring
Deciduous forest	0.2 (7/30)	0.8 (25/30)
Coniferous forest	1.1 (34/30)	1.6 (48/30)
Planted Japanese larch forest	[1.6 (24/15)	1.9 (29/15)]
Mixed forest	1.9 (58/30)	1.3 (38/30)
Total	1.1 (99/90)	1.2 (111/90)

16 m, 8-12 m, 4-8 m, 2-4 m, and <2 m. The relative amount of foliage coverage was estimated according to the following coverage classes: foliage coverage of 0% was coverage class 0, 1-33% coverage class 1, 34-66% coverage class 2, and 67-100% coverage class 3 (Lee 1996). The total vegetation coverage value was expressed as the mean of the coverage class values for every layer within the imaginary cylinder. The habitat structure was surveyed in both winter and spring along the line transects that were censused for hazel grouse.

Results

Hazel grouse occurred in most of the major mountain forest areas in the southern region of the Korean Peninsula (see Fig. 1). They occurred in natural and man-made coniferous, deciduous and mixed forest areas in all investigated elevation zones (Tables 1 and 2) below the timber line. Hazel grouse were observed in 39 out of 45 study sites located on 26 out of 30 mountains. Mt. Chiri (35°20'N, 127°37'E) and Mt. Baekwoon (35°06'N, 127°39'E) were the southernmost localities where the species was observed. The species also occurred in forest areas around Seoul, the capital city of Korea (see Fig. 1).

Hazel grouse were distributed within an altitudinal range of 300-1,200 m a.s.l. (see Table 1), with the highest densities at 600-900 m a.s.l. However, the altitudinal distribution differed between winter and spring. The species inhabited lower altitudes in winter and higher altitudes in spring (Wilcoxon's signed rank test: $Z = -7.343$, $P = 0.0005$). The mean elevation of hazel grouse observations was 607.5 m ± 58.2 (SE) in winter and 857.4 m ± 67.2 (SE) in spring. This suggests a mean seasonal downward movement of 250 m from spring to winter.

There were differences in hazel grouse observations by forest type during winter and spring (χ^2-test: $\chi^2 = 16.05$, df = 2, $P = 0.001$). In winter, 7% of hazel grouse were observed in deciduous forests, 34% in coniferous forests, and 59% in mixed forests. Among the individuals observed in coniferous forests, 24 (24% of the total) were observed in planted Japanese larch forests. In spring, the proportion of individuals observed in mixed forest decreased from 59 to 34%, the proportion of individuals observed increased from 7 to 22% in deciduous forests and remained relatively constant at 34 and 43% in coniferous forests. The proportion of individuals observed in planted Japanese larch forest was rather similar in spring and winter. The selection of habitat types by hazel grouse was significantly different in winter ($\chi^2 = 32.54$, df = 2, $P = 0.002$) and spring ($\chi^2 = 21.45$, df = 2, $P = 0.005$). Hazel grouse selected mixed forest (Bonferroni test: $P = 0.001$) and avoided deciduous forest ($P = 0.001$) in winter. In spring, coniferous forest was selected ($P = 0.002$) and deciduous forest was avoided ($P = 0.002$) as habitat (see Table 2).

Understory vegetation coverage differed between observation and non-observation points of hazel grouse during both winter and spring censuses (Tables 3 and 4). In each forest type, understory vegetation (<2 m) was better developed at observation points in winter (Mann-Whitney U-test: $Z = 4.521$, $P < 0.001$ for deciduous forest; $Z = 3.984$, $P < 0.005$ for coniferous forest; $Z = 3.947$, $P < 0.001$ for mixed forest) and in spring (Mann-Whitney U-test: $Z = 4.325$, $P < 0.001$ for deciduous forest; $Z = 3.258$, $P < 0.001$ for coniferous forest; $Z = 4.592$, $P < 0.005$ for mixed forest) than at non-observation points. However, there were no sig-

Table 3. Mean (± SE) coverage of vegetation layers in deciduous, coniferous and mixed forests at observation and non-observation points of hazel grouse in winter.

Height (m) of vegetation layers	Observation points: Deciduous (N = 21)	Observation points: Coniferous (N = 64)	Observation points: Mixed (N = 121)	Non-observation points: Deciduous (N = 25)	Non-observation points: Coniferous (N = 70)	Non-observation points: Mixed (N = 120)
>20	0.31 ± 0.17	1.84 ± 0.34	1.79 ± 0.23	0.24 ± 0.14	1.99 ± 1.02	0.31 ± 0.34
16-20	0.47 ± 0.23	1.91 ± 0.35	1.87 ± 0.81	0.51 ± 0.26	1.45 ± 0.63	0.81 ± 0.38
12-16	0.21 ± 0.13	1.32 ± 0.46	1.42 ± 0.71	0.31 ± 0.14	1.21 ± 0.65	0.47 ± 0.21
8-12	0.34 ± 0.24	1.48 ± 0.24	1.39 ± 0.18	0.29 ± 0.34	1.54 ± 0.71	0.21 ± 0.13
4-8	0.25 ± 0.34	1.37 ± 0.67	1.42 ± 0.44	0.41 ± 0.12	1.42 ± 0.35	0.74 ± 0.34
2-4	0.62 ± 0.21	1.52 ± 0.41	1.49 ± 0.35	0.43 ± 0.38	1.32 ± 0.41	0.19 ± 0.21
<2	0.54 ± 0.28	1.24 ± 0.27	1.49 ± 0.42	0.21 ± 0.08	0.47 ± 0.34	0.81 ± 0.17

Table 4. Mean (± SE) coverage of vegetation layers in deciduous, coniferous and mixed forests at observation and non-observation points of hazel grouse in spring.

Height (m) of vegetation layers	Observation points Deciduous (N = 57)	Coniferous (N = 131)	Mixed (N = 108)	Non-observation points Deciduous (N = 60)	Coniferous (N = 130)	Mixed (N = 110)
>20	1.86 ± 0.47	1.92 ± 0.61	1.47 ± 0.23	1.78 ± 0.34	1.79 ± 0.26	1.39 ± 0.24
16-20	2.07 ± 0.25	1.87 ± 0.27	1.72 ± 0.37	1.98 ± 0.52	1.81 ± 0.34	1.88 ± 0.58
12-16	2.53 ± 0.39	1.34 ± 0.34	1.82 ± 0.46	2.62 ± 0.45	1.41 ± 0.36	1.90 ± 0.79
8-12	2.42 ± 0.61	1.81 ± 0.38	2.24 ± 0.21	2.44 ± 0.68	1.87 ± 0.08	2.48 ± 0.31
4-8	1.74 ± 0.51	1.45 ± 0.28	1.68 ± 0.54	1.81 ± 0.99	1.43 ± 0.69	1.54 ± 0.28
2-4	1.46 ± 0.23	1.73 ± 0.46	1.62 ± 0.38	1.31 ± 0.35	1.78 ± 0.98	1.47 ± 0.21
<2	1.20 ± 0.32	2.34 ± 0.34	1.81 ± 0.12	,0.51 ± 0.32	0.92 ± 0.32	1.21 ± 0.23

nificant differences in vegetation coverage of mid and high canopy layers (>2 m) between observation and non-observation points neither in winter (Mann-Whitney U-test: $Z = 1.263$, $P = 0.1$ for deciduous forest; $Z = 1.374$, $P = 0.071$ for coniferous forest; $Z = 0.432$, $P = 0.1$ for mixed forest) nor in spring (Mann-Whitney U-test: $Z = -2.131$, $P = 0.081$ for deciduous forest; $Z = 0.685$, $P = 0.06$ for coniferous forest; $Z = 1.397$, $P = 0.06$ for mixed forest; see Tables 3 and 4).

We found a positive correlation between understory vegetation coverage and altitudes of hazel grouse observation points both in winter ($y = 0.41x + 1.05$, $R^2 = 0.51$, $P = 0.02$) and in spring ($y = 0.32x + 1.48$, $R^2 = 0.70$, $P = 0.01$; Fig. 2). The understory vegetation with higher coverage, which was preferred by hazel grouse, was found at lower altitudes in winter than in spring. So, the altitudinal distribution of hazel grouse seemed to be related to seasonal differences in understory vegetation coverage.

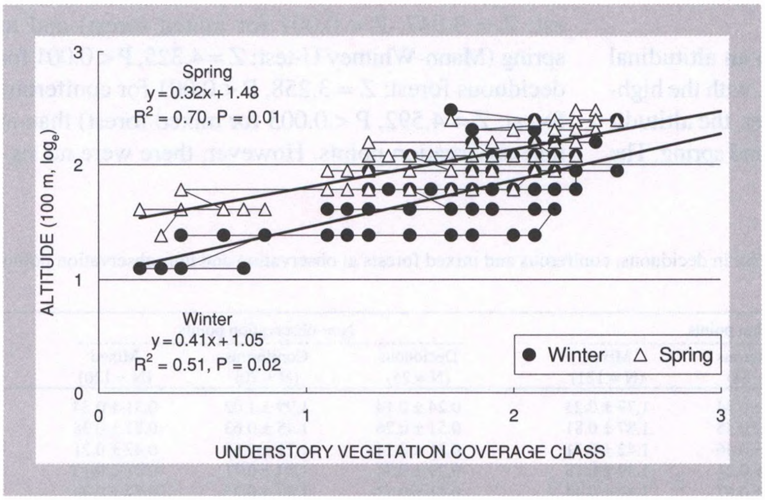

Figure 2. Relationship between altitude and understory vegetation coverage at observation points of hazel grouse in winter and spring.

Discussion

Our results clearly showed altitudinal differences in seasonal distribution (see Table 1) of hazel grouse, and we could observe the flocks in winter. Similar results of differences in seasonal distribution of hazel grouse have been reported from the Changbai Mountains in China (Zhao 1977). However, no difference in the seasonal distribution of hazel grouse was reported from a flat area in Sweden, i.e. the species showed a very high degree of site fidelity, staying within a relatively small area throughout the year (Swenson 1991b, Swenson 1995, Swenson & Danielsen 1995).

We found a significant correlation between altitude and understory vegetation coverage at hazel grouse observation points in winter and spring (see Fig. 2). Also, understory vegetation coverage was more developed at observation points than at non-observation points of hazel grouse in winter and spring (see Tables 3 and 4). This suggests that the seasonal distribution of the species may be related to the coverage of understory vegetation. The shifts in seasonal use of areas may also have been affected by the distribution of the most important seasonal foods, as was found in Sweden (Swenson & Danielsen 1995), i.e. spring and winter foods may be spatially separated. The lower use of deciduous forests in winter may have been due to less cover in this habitat during winter; the lower use of coniferous forests in winter may have been due to less winter food in this habitat. The winter diet of hazel grouse mainly consists of buds and catkins of willow *Salix* spp., birch *Betula* spp. and alder *Alnus* spp. (Rhim & Lee 2000). Thus, the increased use of mixed forests in winter may have been due to a more favourable combination of food and cover (Swenson, Andreev & Drovetski 1995). More detailed research on the seasonal availability of and changes in hazel grouse food in each habitat is needed to clarify the mechanisms behind the distribution of hazel grouse.

Hazel grouse occurred in three major types of forests in southern Korea. Use of forest types probably reflects a need for cover as well as for food (Yang & Meng 1994, Beshkarey et al. 1995). Swenson (1995) reported results similar to ours, i.e. that hazel grouse habitat usually has dense cover from the ground to about 2 m above ground, and that the overstory is less important. Thus, the understory vegetation is probably a critical factor for the species, and the presence of hazel grouse seemed to be related more to the development of understory vegetation than to forest type in southern Korea.

Hazel grouse occurred in most of the major mountain forest areas in southern Korea (see Fig. 1). Our results indicate that the southern limit of the hazel grouse range on the Korean Peninsula was somewhat farther to the south, namely Mt. Baekwoon (35°06'N, 127°39'E), than previously reported (Johnsgard 1983, Koo & Lee 1990, Han & Fujimaki 1996).

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