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The Relationship between Breeding Bird Community and Forest Structure at a Deciduous Broad-leaved Forest in Hokkaido, Japan

Lee, Woo-Shin

Wildlife Management Division, Forestry Research Institute, Seoul 130-012, Korea

일본 북해도 낙엽활엽수림의 산림환경구조와 번식 조류 군집과의 관계

이 우 신

임업연구원 야생동물과

ABSTRACT

This study was conducted to clarify the relationship between bird community and forest structure from early May to mid June, 1988 in two sites which had different forest structures due to silvicultural practice, located in the Tomakomai Experimental Forest of Hokkaido University, Hokkaido, Japan.

Quantitative habitat analysis was applied to elucidate difference between the two study sites, and territory mapping method and guild analysis were used for assessment of the bird community. Dominant tree species were *Quercus mongolica, Magnolia obovata, Prunus sargentii, Acer mono* and *Tilia japonica*. Unthinned site had more foliage coverage in upper and middle layers, but in lower layer had less coverage than thinned site. Thirty four species of birds were recorded and of them only 21 species occupied territories within the study area. Dominant species were *Ficedula narcissina, Phylloscopus occipitalis, Parus major, Passer rutilans, Sitta europaea* and *Parus palustris* in the study area. The number of breeding species of the two sites were equal, but the species composition of breeding bird communities was different between the sites. The number of species and pairs on hole-nesting guild were greater in the unthinned site, but those on ground-nesting guild were greater in the thinned site. Canopy-nesting guild showed no significant difference between the two sites. Silvicultural practice such as proper thinning appeared to be not inadequate to all of the forest birds, probably good to bush and ground nesting guild, and to tree & bush and ground foraging guild. The silvicultural practice also did not considerably affect the hole and canopy-nesting guild.

Key words: Bird community, Foraging guild, Forest structure, Nesting guild, Thinning

INTRODUCTION

Since the MacArthur's model (1961), many researchers have been endeavored to verify the model and to elucidate factors which influence bird species diversity. There have been many factors suggested by various researches that explain bird species diversity. These are classified into three categories :

The first is the hypothesis that vertical distribution of foliage profile in a forest affects bird species diversity (MacArthur and MacArthur 1961, Recher 1969, Karr and Roth 1971). The second is that horizontal distribution of foliage profile influences bird species diversity (Roth 1976, Blondel and Cuvillier 1977, Erdelen 1984). The third is that a taxonomic composition of the habitat is a good factor explaining bird species diversity (Tomoff 1974, James and Wamer 1982, Hino 1985).

The purpose of this study is to clarify the relationship between bird community and forest structure at two sites which showed different forest structure due to silvicultural practice such as thinning. In addition, the effect of thinning on the structure of bird community was investigated, and ultimately a sustainable forest management system which would be in harmony with silvicultural practice and bird species diversity was suggested.

STUDY SITES AND METHODS

The Tomakomai Experimental Forest of Hokkaido University is located at Tomakomai (42°41′N, 141°36′E) in the southern Hokkaido, and has an area of 2,715 ha. The forest was originally a mixed forest of coniferous and deciduous broad-leaved trees at an altitude of 50~90 m. The mean temperature recorded at the meteorological station of the Experimental Forest was 10.3℃ in May, and 13.3℃ in June, 1988.

Two study sites were selected in a deciduous broad-leaved forest, and the size of each study site was 9 ha (300×300 m). An unthinned site was made along a forest road. A thinned site was passed through by forest roads and some trees of this site were cut in the winter from 1982 to 1983. The logged timbers were abandoned within the thinned site. Census was conducted from early May to mid June, 1988.

For quantitative description of the habitat, variables of the forest structure such as height, diameter, type, species and number of trees were recorded at plots of 5 m diameter in each quadrat (25×25 m). The classification of foliage height and foliage coverage of each forest layer was determined as follows:

Foliage height was classified into seven layers according to vertical direction. Layer A was above 16 m, layer B was 11.5~16 m, layer C was 7.5~11.5 m, layer D was 5.3~7.5 m, layer E was 3.3~5.3 m, layer F was 1.5~3.3 m, and layer G was below 1.5 m. Relative amount of foliage coverage was evaluated into numeric value, e.g., foliage coverage of 0 % into 0, 1~33 % into 1, 34~66 % into 2, and 67~100 % into 3.

Tree types were classified by height and diameter at breast height (DBH). Mean height and DBH of type A were 21±3m and 27±10 cm, respectively; those of type B were 13±1m and 14±4 cm; those of type C were 10±1.3m and 7.6±4.3 cm; those of type D were 6.1±0.9m and 4±1.3 cm; those of type E were 4.3±0.6m and 2.3±0.7cm; those of type F were 2.6±0.5m and 1.7±0.5cm; those of type G (the bush) were lower than type F.

Bird communities were censused by using the territory mapping method developed by Kendeigh (1944). For the census, two census trails were made, running parallel to each other at 25 m intervals in the quadrat and being used alternatively. The mapping census was conducted by walking along the trail at an average speed of 1.5 km per hour. Species, number, sex, location and activity were recorded on a map for all birds heard or seen within 25m either side of the census trail. Nests of birds were investigated while censusing or after the census. The number of pairs was calculated for each species from the number of territorial males. A bird having a territory was considered to be in a pair, although the presence of mates was not always ascertained for some species. When the boundary of a territory reached outside the quadrat, the bird was treated as 0.5 pair. Some species having no territory in the quadrat were considered as an accident.

In the analysis of bird communities, the guild concept was used. According to the nesting and foraging site of breeding species, the breeding community was classified into the nesting and foraging guild by using Haapanen's criteria (1965). Nesting guild was distinguished into hole, tree, bush, ground and others, and foraging guild was divided into tree & bush, ground, and air (Table 5).

Species diversity index of bird communities was analyzed by Shannon-Wiener Index (Shannon and Weaver 1949). The equation is as follows;

$$H' = \sum_{i=1}^{S} (-P_i) \times \ln(P_i),$$

Where, S is a total number of species observed, P_i is a proportion of i species and H' is a diversity index.

RESULTS AND DISCUSSION

Forest environment

In the study area, dominant tree species were *Quercus mongolica, Magnolia obovata, Prunus sargentii, Acer mono, Tilia japonica* and *Fraxinus lanuginosa.*

Fig. 1 depicts foliage height profile in the study area, and mean foliage coverage of foliage layers was statistically compared among 242 study quadrats as shown in Table 1. Unthinned site had more foliage coverage in the layers B, C, D and E, but had less coverage in the layers A, F and G than did thinned site. Difference in foliage coverage was statistically significant in layer B ($t = 3.62$, $P<0.0004$), C ($t = 7.85$, $p<0.0001$), D ($t =$

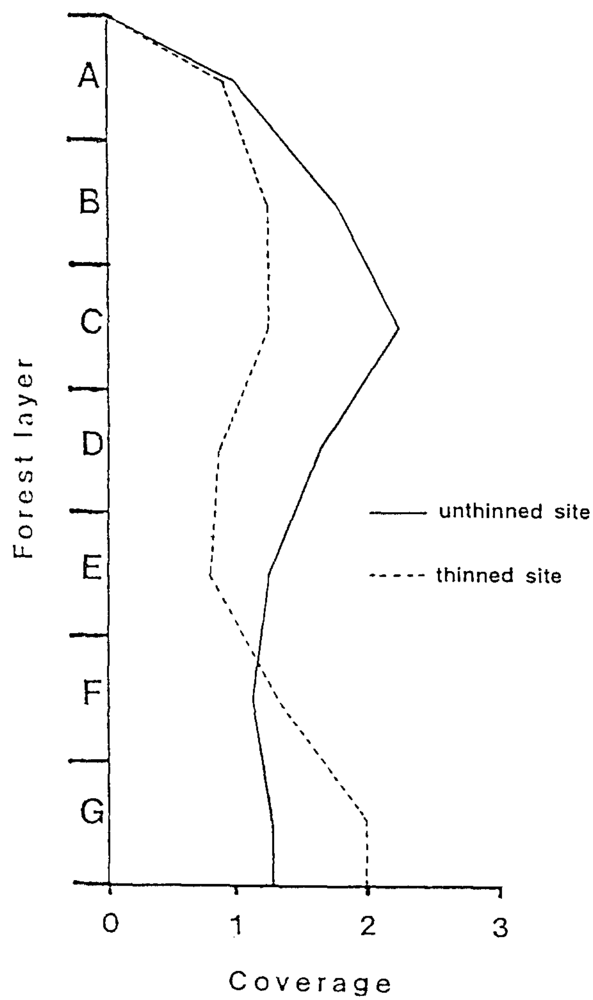

Fig. 1. Foliage height profile.

8.13, $p<0.0001$), E($t = 6.93$, $p<0.0001$) and G($t = -8.11$, $p<0.0001$) layers.

In tree density analysis, the unthinned site was higher than the thinned site in tree type A, B, C, D, and E. But it was reversed in type F (Table 2).

The difference of mean foliage coverage between sites was apparent in layers D and G, and tree density was lower in thinned site except tree type F. These could be attributed to silvicultural practice and growth of ground layer for 5 years after thinning during winter from 1982 to 1983.

Bird community

In Table 3, 34 species of birds which had been observed were shown, and 21 species of them occupied territories within the study area. In terms of migration, 10 species were summer visitors and the other 11 species were residents. The result was consistent with Fujimaki's report (1986). There were 10 residents and 8 summer visitors in unthinned site, while 8 residents and 10 summer visitors were recorded in thinned site.

Table 1. Comparison of mean foliage coverage between study sites (N=242) by t-test

Foliage layer	Unthinned site	Thinned site	t-value	Prob>t
A	0.95	0.98	−0.22	0.8265
B	1.78	1.24	3.62	0.0004
C	2.25	1.26	7.85	0.0001
D	1.65	0.87	8.13	0.0001
E	1.26	0.80	6.93	0.0001
F	1.14	1.31	−2.36	0.0192
G	1.30	1.99	−8.11	0.0001

Table 2. Tree density according to tree types A, B, C, D, E and F in Tomakomai Experimental Forest of Hokkaido University (number of trees /ha)

Tree	Type A	Type B	Type C	Type D	Type E	Type F
Unthinned site	235.3	336.8	757.9	1254.7	1069.5	1557.9
Thinned site	197.9	244.2	336.8	227.9	724.2	2433.7

The dominant species were *Ficedula narcissina, Phylloscopus occipitalis, Parus major, Passer rutilans, Sitta europaea* and *Parus palustris* in the study area. Unthinned site showed the same order of dominant species in study area, but thinned site showed the dominant species as follows; *Ficedula narcissina, Phylloscopus occipitalis, Cettia squameiceps, Parus major, Emberiza cioides, Emberiza spodocephala, Passer rutilans, Sitta europaea* and *Parus palustris*.

Compared with Fujimaki(1986)'s work studied in the same study area, the species composition resulted from this study was similar to his study. Also, species composition was not so different between the sites in this study. So, these results suggest that the bird species composition remained relatively stable after logging, and silvicultural practice such as thinning did not cause remarkable difference in the species composition of forest bird. However, Hagar (1960) found marked change of avian species composition after logging.

The difference between this study and Hagar's was thought to be caused by the differences in habitat condition (i.e., food availability and quality, cover, nest sites, tree density, amount of open-ground, amount of canopy) of the two studies (Franzreb and Ohmart 1978).

For both sites, it was one of the typical feature of deciduous broad-leaved forest in Hokkaido that *Ficedula narcissina* and *Phylloscopus occipitalis* were the most dominant species. It was also corresponded with the study of Ishigaki and Matsuoka (1972) and Fujimaki (1986) in Tomakomai Experimental Forest.

Fifteen species bred in both sites, but three species such as *Parus various, Garrulus glandarius* and *Certhia familiaris* did only in the unthinned site, and in the thinned site did only 3 species such as *Emberiza cioides, Anthus hodgsoni* and *Carduelis sinica* (Table 3).

In Table 4, the number of breeding species was equal in the two sites, but the thinned site had a higher number of breeding pairs. Temporarily visiting birds were 12 species in the unthinned site and 9 species in the thinned site. Species diversity indices were 2.52 in the unthinned site and 2.60 in the thinned site. There were no significant difference in species diversity indices and number of breeding species between the two sites. This fact suggested that the suitable thinning in forest might not affect the bird community.

Cettia squameiceps bred only 1 pair in the unthinned site, but 5 pairs did in the thinned site. *Emberiza cioides* bred only 4 pairs in the thinned site, and *Emberiza spodocephala* bred 0.5 pair in the unthinned site but 3.5 pairs in the thinned site. So, the thinned site had more breeding pairs than unthinned site.

In Table 5, the communities of breeding birds were analyzed in two study sites in terms

Table 3. Number of pairs of birds observed in the study sites

Species	Unthinned site	Thinned site	Total	Mig.
Ficedula narcissina	8	7.5	15.5	S.V.
Phylloscopus occipitalis	5.5	6	11.5	S.V.
Parus major	5	4	9	Res.
Parus palustris	3	2.5	5.5	Res.
Parus ater	+	+	+	Res.
Parus varius	1		1	Res.
Sitta europaea	3	3	6	Res.
Aegithalos caudatus	+	+	+	Res.
Dendrocopos leucotos	0.5	0.5	1	Res.
Dendrocopos major	1	1	2	Res.
Dendrocopos kizuki	1.5	2	3.5	Res.
Picus canus	+		+	Res.
Cettia squameiceps	1	5	6	S.V.
Emberiza cioides		4	4	S.V.
Emberiza spodocephala	0.5	3.5	4	S.V.
Eophona personata	1	0.5	1.5	S.V.
Fringilla montifringilla	+		+	W.V.
Passer rutilans	3.5	3.5	7	S.V.
Hypsipetes amaurotis	1	1	2	Res.
Muscicapa latirostris	1	1	2	S.V.
Cyanoptila cyanomelana	1	0.5	1.5	S.V.
Garrulus glandarius	0.5		0.5	Res.
Carduelis sinica	+	1	1	Res.
Certhia familiaris	1	+	1	Res.
Corvus machrorhynchos	+	+	+	Res.
Zoster japonica	+	+	+	S.V.
Coccothraustes coccothraustes	+	+	+	S.V.
Streptopelia orientalis	+	+	+	S.V.
Turdus naumanni	+		+	W.V.
Turdus cardis	+		+	S.V.
Tetrastes bonasia	+		+	Res.
Gallinago hardwickii		+	+	S.V.
Phylloscopus borealis		+	+	S.V.
Anthus hodgsoni		1	1	S.V.

Plus marks indicate that the species were present in the quadrat but had no territories.
Mig.: migration, Res.: residents, S.V.: summer visitors, W.V.: winter vistors.

Table 4. Difference in bird community between unthinned site and thinned site in breeding season

	Unthinned site	Thinned site	Total
Breeding species richness	18(12)*	18(9)*	21(13)*
Number of breeding pairs	39	47.5	86.5
Breeding pairs /ha	4.3	5.3	4.8
Bird species diversity	2.52	2.60	2.66

* Values in the parenthesis show the number of species which were present in the study sites but had no territories.

Table 5. Number of species and pairs according to guilds

Nesting or foraging guild	Unthinned site	Thinned site
Nesting guild		
Hole	9(19.5)*	7(16.5)
Tree	5(11.5)	5(11)
Bush	2(1.5)	2(8.5)
Ground	1(5.5)	3(11)
Others	1(1)	1(0.5)
Foraging guild		
Tree & bush	14(28.5)	13(34)
Ground	1(0.5)	2(4.5)
Air	3(10)	3(9)

* Values in the parenthesis show the number of pairs.

the nesting and foraging guild. The number of species and pairs on hole-nesting guild were higher in the unthinned site than in the thinned site. While those of ground-nesting guild were reverse.

Thinning causes less coverage of layer C and D ($p>0.0001$), which in turn is associated with fewer numbers of the hole-nesting guild. It is noted that tree type A and B are the major source of the hole-nesting guild (Table 2).

In spite of decrease in tree density and coverage due to thinning, tree-nesting guild had no significant difference between unthinned and thinned sites. This result suggested that the tree-nesting guild was mainly composed of cup type nest on twigs, and is not closely related to the tree density and coverage (Table 2, Fig. 1).

Hino (1985) showed that the density of hole and canopy-nesting guild was correlated positively with cover in farmstead shelterbelts in Hokkaido, and each ecological group except for bush and ground foraging species showed slight variation in number of pairs.

For the bush-nesting guild, the two sites showed an equal number of species. However, number of pairs was higher in the thinned site. It would be due to the high coverage of layer G ($P>0.001$) in the thinned site. This indicated that canopy cover and floor vegetation may be important to birds of the bush-nesting guild (Hino 1985).

In the point of foraging guild, the number of species was the same in the two sites. However, except for air-foraging guild, pairs of ground foraging guild was higher in the unthinned site. This result might be caused by the high coverage of layer G. In the air-foraging guild, there was no difference in both sites.

These results indicated that small scale and proper thinning did not significantly affect the tree-nesting and air-foraging guild. However, augmentation of ground layer and bush layer in an ecotone due to silvicultural practice such as thinning not only attract not only ground-nesting guild, such as *Emberiza spodocephala* and *E. cioides*, but also enlarge the population size of bush-nesting guild, such as *Cettia squameiceps*.

In conclusion, silvicultural practice such as proper thinning may not affect negatively to

all of the forest birds, rather be beneficial to bush and ground nesting guild and tree & bush and ground foraging guild. In addition, silvicultural practice do not affect the hole and canopy-nesting guild. These results may imply that proper thinning technique would be applied to conserve biodiversity in forest ecosystems and to maintain sustainable forest management.

적 요

이 연구는 1988년 5월 초순부터 6월 중순까지 일본 북해도 대학 토마코마이 연습림에서 산림시업에 의한 산림구조가 다른 두 지역에서 산림환경구조와 번식조류군집과의 관계를 밝히기 위하여 이루어졌다. 조사지간의 차이를 밝히기 위한 정량적인 서식지분석과 조류군집을 평가하기 위한 세력권 도시법과 길드분석을 하였다. 우점수종은 신갈나무, 일본목련, 산벚나무, 고로쇠나무 등이었다. 임층의 피도는 상중층은 비간벌지가, 하층은 간벌지가 높았다. 조사지에서 34종의 조류가 관찰되었고 21종이 세력권을 확보하였다. 황금새, 산솔새, 박새, 섬참새, 동고비, 쇠박새가 우점종이었다. 조사지간에 번식조류의 종수는 동일하였으나 조류군집구성은 달랐다. 수동영소길드 조류 종수와 쌍수는 비간벌지에 많았으나, 지면영소길드 조류는 간벌지에서 많았다. 그리고 수관층영소길드는 조사지간에 유의한 차이가 없었다.

그러므로 적정한 간벌과 같은 산림시업은 모든 산림조류에 부적당한 것이 아니고 관목, 지면영소길드와 나무와 관목, 지면채이길드에 유리한 것으로 생각되었다. 또 산림시업이 수동과 수관영소길드에 큰 영향을 미치지 않았다.

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