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Vertical Distribution of Foraging Tits in Mixed Species Flocks in Urban Forests

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ABSTRACT: In December-January of 1996-1997 and 1997-1998, information was gathered about vertical distribution of foraging sites of tits in 34 flocks in coniferous and deciduous forests. There was a significant effect of forest type on the distribution of foraging sites of each species. Habitat was classified into 5 height layers vertically: ground, bushes (usually < 1.5 m, up to 3 m), tree layer 1 (up to 1/3 of tree height), tree layer 2 (1/3-2/3 tree height), and tree layer 3 (>2/3 tree height). There were differences among species: great tit (*Parus major*) foraged mostly on the ground, coal tit (*P. ater*) and long-tailed tit (*Acrocephalus caudatus*) - on the highest tree layer, marsh tit (*P. palustris*) was often seen on bushes, and varied tit (*P. varius*) - in tree layer 2. Smaller species used upper and outer parts of trees, suggesting that, like in most other similar studies, larger dominant species prevented smaller species from using inner parts of trees.

Key Words: Foraging, Korea, Mixed flocks, *Parus* species, Urban forests, Tits, Wildlife.

INTRODUCTION

Mixed species flocks of tits in winter have been studied intensively in boreal forests of Europe (e.g. reviews in Alatalo 1982 and Alatalo et al. 1986 and research reports in Alatalo and Moreno 1987, Alatalo *et al.* 1987, Dhondt 1989, Ekman 1989, Ekman *et al.* 1981, Hogstad 1989, Suhonen *et al.* 1992, Suhonen 1993, Suhonen *et al.* 1993, 1994). They serve as good model systems to illustrate various factors important in evolution of individuals and ecological communities. The conclusions from these studies have broad significance, yet they are based only on results from a small proportion of the geographical area where winter flocking occurs, and on a small subset of species involved in such behaviors. Although studies in North America (e.g. Hamerstrom 1942, Dixon 1965, Smith 1967, Hartzler 1970, Yaukey 1995) and in temperate zone of Europe (e.g. Szekely *et al.* 1989, Sasvari 1992, Carascal and Moreno 1992) confirm general conclusions of the European boreal studies, there are not many reports about division of ecological niches among flock members in habitats of continental Asia, and no paper concerns Asian temperate forests. This is the first report about the distribution of foraging sites in flocks of tits in continental temperate forests in Asia.

METHODS

In the period of December to January in 1996-1997 and 1997-1998 the author has observed tits in forests on the slopes of mountains near Seoul (within 50 km from the city): Seoul National University Botanical Garden in Suwon, Chilbo Seoul National University Forests, Anyang Seoul National University Botanical Garden, South Seoul National University Forests, Mt. Suri Forests, Mt. Kangyo Forests, Seoul Grand Park in Kwachun. The forests consisted of pines (*Pinus rigida, P. densiflora, P. koraiensis*), firs (*Abies holophylla*), or oaks (*Quercus acutissima, Q. aliena, Q. mongolica, Q. serrata, Q. variabilis, Q. dentata*) mixed in various proportions. *Alnus japonica, Robinia pseudo-acacia, Castanea crenata, Rhododendron* spp., *Prunus* spp., *Betula* spp., *Zelkova serrata*, etc. were also present.

After finding a flock forest type and time of a day were recorded. Forests that were composed of only conifers (pines or firs) were classified as Coniferous. Other forests, with various proportions of deciduous trees (40-90%) were classified as Mixed. The obser- vations among forest types equally were distributed with respect to time of a day. Each flock was followed for 0.5-2.5 hours and foraging site positions of birds were recorded with regard to height (Table 1):

To resolve the problem of interdependence of subsequent records of the same individuals, after each record the direction of search was changed for the next bird in the flock by 90-270 degrees. Additionally, re-record was not attempted to the same individual within 30 seconds from the last observation even though it was possible to follow it. Usually, the same bird was difficult to find again and was recorded again after

Table 1. Vertical distribution in tree height at which birds were observed

Code	Vertical distribution	Distribution in tree height
G	Ground	Ground floor in forests
B	Bush	Mostly < 1.5 m, up to 3m
T1	Tree layer 1	Height ≤ 1/3 of the tree height
T2	Tree layer 2	1/3 - 2/3 of tree height
T3	Tree layer 3	> 2/3 tree height

several minutes or so.

Each flock was treated as a separate data point in the statistical analysis. For each flock, proportions of records were calculated during which birds of a given species were seen at a given Height. For statistical analyses height was treated as a factor extending across the whole habitat (all observations of a given species in the flock summed up to 100%).

Two-factor repeated measures ANOVA was used to study the effect of forest type (FT-between subject factor) and the effect of Height (H) on frequency of observations for each species separately. For these analyses, the proportions were transformed according to the formula: transformed variable = $\arcsin(\sqrt{x})$ (Zar 1984).

To study whether vertical distributions differed among species interaction effects were calculated in repeated measures ANOVA's with flock and species as within-subject factors, using only those flocks in which both species were present. The subsets of data used in each such analyses overlapped to some extent, but usually not more than 50%.

Three less numerous species (*Sitta europaea*, *Regulus regulus* and *Dendrocopos kizuki*) foraged exclusively on trees. All observations were summarized from all the flocks to see whether frequency of observations depended on vertical zone. Chi-square test was used to compare the observed frequency with the frequency expected if birds foraged equally often at various heights.

RESULTS

The mixed species flock of tits were: *Parus palustris*, *P. major*, *P. ater* and *P. varius*. The flocks also contained *Acrocephalus caudatus* and occasionally: *S. europaea*, *D. kizuki*, *D. major*, *R. regulus*.

There was a significant effect of Height on foraging site distribution in each species separately (Fig. 1), with the exception of *P. varius* and *A. caudatus*. The distributions differed between the two forest types (interaction effects' $F=3.00$, $df=4$, $p=0.021$) indicating that species-specific foraging behaviour existed across the forest types. *P. varius* was mostly seen at height layer T2 (Fig. 1E), *P. major* - on a ground (Fig. 1C), *P. palustris* - mostly in bushes, but also quite often in T2 (Fig. 1D), *P. ater* (Fig. 1B) and *A. caudatus* (Fig. 1F) were foraging in higher parts of trees. *S. europaea*, *D. kizuki*, and *R. regulus* exclusively foraged in the crown area of trees so that the separate χ^2 test was performed and indicated that there were differences of foraging behavior in tree layers in *S. europaea* and *R. regulus* (Table 2).

The vertical distributions differed significantly among species for most comparisons in which a difference between the two species (interaction term in repeated measures ANOVA with flock and species as within-subject factors) was calculated (Table 3). Patterns of vertical distribution generated from the subsets of data used for such comparisons were very similar to the patterns produced from the whole set of data.

DISCUSSION

There was a clear difference in the use of habitat between the two forest types (coniferous vs. deciduous). Difference in forest types suggested that distribution of foraging sites should be the effect of structural characteristics of the two forest types. In winter the coniferous trees form leaves and small twigs, potentially providing better hiding place for mixed species of tits, thus influencing an habitat segregation of the flock and species interactions.

Significant differences among species suggested that the vertical distributions were characteristics of the species forming the flock and the result of interactions between those species. Additionally they appeared to be universal over large geographical areas. For example, *P. ater* prefers higher, outer tree parts in Europe (e.g. Alatalo *et al.* 1987, Suhonen *et al.* 1993), Japan (Ogasawara 1970) and Korea (this study). Like in this study, *P. major* in Japan (Ogasawara 1970) and temperate Europe (Sasvari 1992) often uses ground for foraging.

In general, due to competition between species in tit flocks, larger species forage in the inner tree parts, while smaller species use the outer foliage and twigs (Alatalo and Moreno 1987). Accordingly, only the two largest species in this study (*P. varius*: weight 14-20g, body length about 14.0 cm, and *P. major*: 12-13.5 g, 14.5 cm, Won 1981) used the inner part more often than outer parts of a tree. The smallest species, *P. ater* (body length = 11 cm), used mostly outer zone, and intermediate in body size, *P. palustris* (body length = 12.5 cm), did not favor any

horizontal zone within a tree. Furthermore, *P. major* favored ground presumably where the food resources were abundant, and *P. varius* used more frequently in bush and crown 2 layer. During observations *P. varius* was prominent in cashing behaviour that they hid food resources (insects, and pine seeds) in bark so that most of feeding behavior took place on the ground and bushes. *A. caudatus* was not directly competitive to mixed tits that resulted in T3 of the highest area of trees. Separation of feeding areas suggested that dominance relationships within a flock should be an important factor shaping foraging niche of each flock member. There were abundant small twigs,

Table 2. Vertical distribution of *Sitta europaea*, *Dendrocopos kizuki* and *Regulus regulus* in trees. N indicates total number of observations.

Species	N	Height			χ^2	df	P
		T1	T2	T3			
Sitta europaea	30	2	17	11	11.4	2	<0.003
Regulus regulus	12	0	5	7	6.5	2	<0.038
Dendrocopus kizuki	8	1	3	4	1.73	2	<0.420

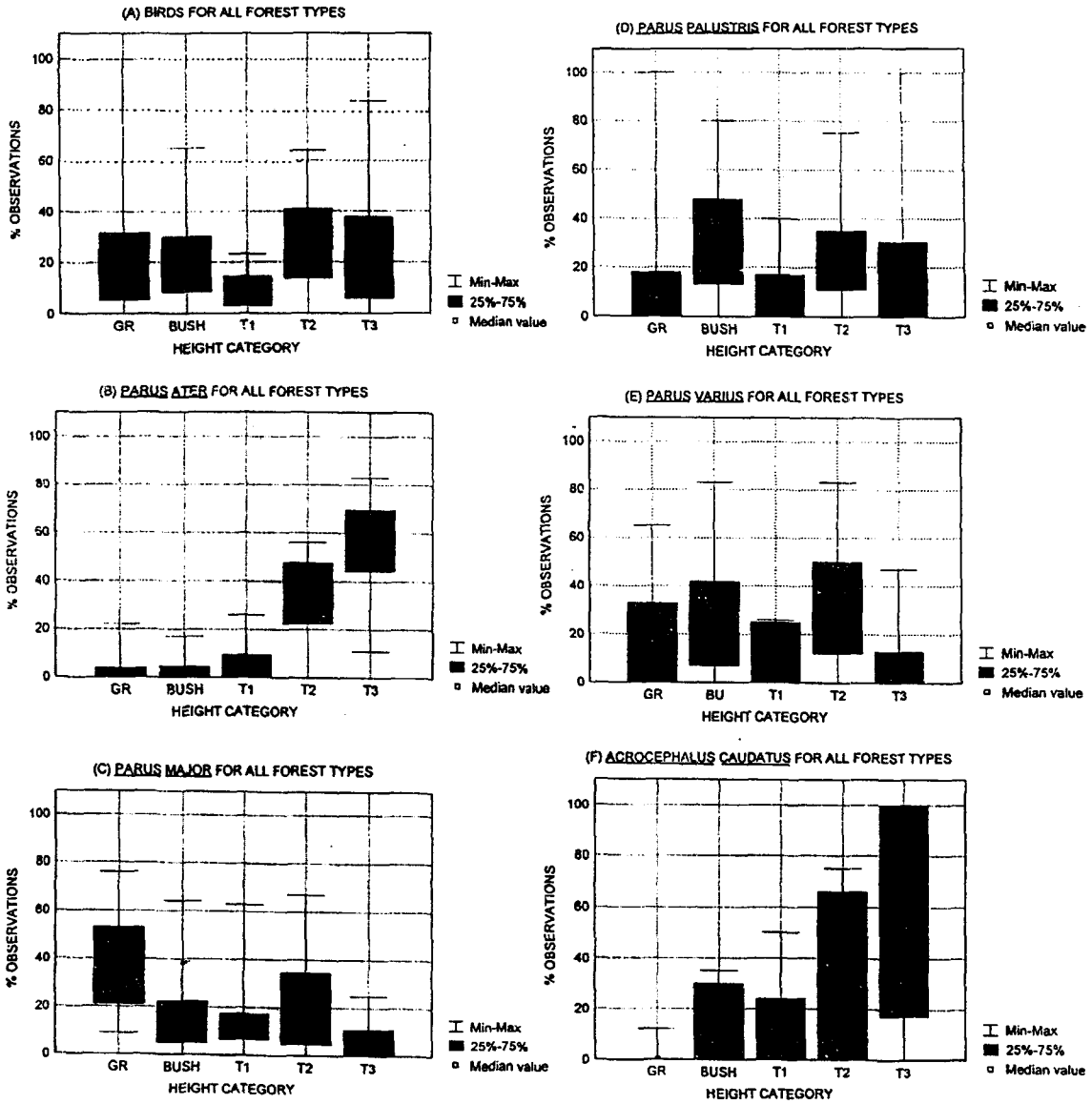

Fig. 1. Height (vertical) distribution of five species and all birds in two forest types : A - all birds (effect of Height: FH=3.07, df=4, p=0.0185; effect of interaction Forest type x Height: FI=3.95, df=4, p=0.0046); B - *P. ater* (FH=25.90, df=4, p=0.00; FI=1.22, df=4, p=0.32); C - *P. major* (FH=6.77, df=4, p=0.0001; FI=0.71, df=4, p=0.59); D - *P. palustris* (FH=3.99, df=104, p=0.005; FI=1.56, df=104, p=0.19); E - *Parus varius* (FH=2.05, df=4, p=0.12; FI=0.08, df=4, p=0.99); F - *Acrocephalus caudatus* (FH=1.05, df=4, p=0.42; FI=0.64, df=4, p=0.64); GR=Ground, BUSH=Bush, T1=Tree layer1, T2=Tree layer2, T3=Tree layer3.

Table 3. Comparisons of species with regard to vertical distributions. Results of repeated measures ANOVA with Height (vertical distribution) as one within-subject factor and Species (two species entered each analysis) as another within-subject factor. Each flock served as one data point.

Pair of Species	N	Interaction: Height × Species
P. varius *P. major*	4	F=2.241, df=4, p=0.125
P. varius *P. palustris*	8	F=8.499, df=4, p=0.000
P. varius *P. ater*	4	F=10.505, df=4, p=0.001
P. major *P. palustris*	18	F=2.715, df=4, p=0.037
P. major *P. ater*	9	F=7.408, df=4, p=0.000
P. palustris *P. ater*	12	F=11.258, df=4, p=0.000

branches and leaves in upper layers of tree, and the highest areas in crown presumed large energy consumption to forage in and out of trees, and also potentially exposed to predation. This assumption needs to be clarified in the experimental aproaches between foraging behavior and predation.

In summary, this study shows that foraging site distributions of tits of mixed species flocks in Korea differ in the two habitat types: coniferous and mixed forests. The differences between large and small species in habitat use suggest an influence of within-flock dominance interactions on foraging site distributions of small, and therefore subordinate species.

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