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Tree Species Preference and Inter-specific Difference of Foraging Maneuver, Trees and Location among Four Canopy-dwelling Birds at High-elevation Temperate Deciduous Forest in Mt. Jumbongsan

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Abstract: This study was conducted to reveal tree species preference and inter-specific difference of foraging behavior among four canopy-dwelling birds at forest dominated by *Quercus mongolica*, *Acer pseudosieboldian* and *Carpinus cordata* at 1,000 meters above sea level during breeding season of birds from 1995 to 1997 in Mt. Jumbongsan. Breeding birds were about 25 species and dominant birds were *Erithacus cyane*, *Parus ater* and *Parus palustris*. A relatively high number of bush-nesters can be a characteristic of breeding bird community at study area. Three gleaners (Tits, *P. varius*, *P. palustris* and *P. ater*) selectively preferred the trees irrespective of dominant tree species, whereas bark foragers (Nuthatch, *Sitta europaea*) utilized the dominant trees. The four birds showed significant inter-specific difference in use of foraging location, but the three tits did not show significant inter-specific difference in use of foraging maneuver and trees. Closely related tits may coexist with each other by inter-specific different use of foraging location determined by foliage structure and leaf arrangement.

Key words: Tits, nuthatch, foraging behavior, tree species preference

Many studies have correlated avian abundance and diversity with specific structural characteristics such as foliage height diversity and stem density (MacArthur and MacArthur, 1961; MacArthur et al., 1966; Austin, 1970; Recher, 1969; Karr and Roth, 1971). However, tree species composition can affect avian community structure (Gabbe et al., 2002) and foraging behavior (Unno, 2002). Especially tree characteristics such as leaf arrangement can be an important factor in prey detectability and accessibility to birds (Holmes and Schultz, 1986; Holmes et al., 1979; Robinson and Holmes, 1982). Morphological and behavioral adaptations for procuring food (Moreno and Carrascal, 1993) and differences in prey abundance among tree species (Hino et al., 2002) may lead to foraging preferences for certain tree species, which can, in turn, dictate the distribution and abundance of birds. So, tree species preference of birds can be determined by foliage structure, prey abundance and eco-morphological traits of birds. In East Asia, there are five tits (*Parus major*, *P. varius*, *P. montanus*, *P. palustris*, and *P. ater*), and four tits except for *P. montanus* breed all over Korea (Lee et al., 2000). However, it is very rare to observe breeding individuals of *P. major* in high-elevation areas (Lee et al., 1997). And, it is meaningful to elucidate the inter-specific interactions among *P. varius*, *P. palustris* and *P. ater*, where socially dominant species *P. major* is absent. I selected dominant birds three canopy foragers such as *P. major*, *P. palustris*, *P. ater* and one bark forager *Sitta europaea* in the study area (Lee et al., 1997). I asked tree species preference of the four birds with respect to tree composition, foraging maneuver, foraging locations and tree preference. This study was conducted to reveal tree species preference of canopy-dwelling birds at high-elevation temperate deciduous forest.

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STUDY AREA AND METHODS

Study area

This study was conducted at Mt. Jumbongsan (38º00′~38º03′ N, 128º26′~128º30′ E) in Kangwon Province, South Korea. I chose a 10 ha study area in size of 250×400 m^2 at the valley and ridge area from 950~1,050 m a.s.l., and established 160 plots in size of 25×25 m^2 in December, 1995.

The relative importance value (IV) of each tree species was calculated as the percentage of basal area, which is closely correlated with leaf surface area (Holmes and Robinson, 1981). This forest represents a deciduous forest dominated by *Quercus mongolica*, *Acer pseudosieboldianum* and *Carpinus cordata* (Cho and Lee, 2001). At the herbaceous layer, dominant species were *Ainsliaea acerifolia*, *Sasa borealis*, *Meehania urticifolia* and *Deutzia glabrata*.

Breeding bird communities at Mt. Jumbongsan and Gwangneung Forest

I surveyed the breeding bird communities from mid April to mid July at Mt. Jumbongsan in 1995, 1996 and 2004, and at Gwangneung forest in 2004 by territory mapping methods. I visited nine times during breeding season and I walked along lines at interval of 50 m grids for 3 h in the study area. The locations of all birds, and particularly singing males and nest sites, were mapped on paper replicas of the plot during the series of visits. These individual visits were transcribed to species-specific sheets at the end of the season and territory boundaries were identified for individual males or pairs. I followed the protocol for interpreting the territory boundaries suggested by Bibby et al. (2000). For characterization of the species composition of breeding bird community, I compared the composition of nesting guild with the data of breeding bird communities obtained in 1994 and 1995 at Gwangneung forests (Kim et al., 1996). Gwangneung forests (37°45′~38°46′N, 127°9′~127°10′E) are located at the elevations of 340 m a.s.l., and dominated by *Q. serrata*, *Carpinus laxiflora*, *C. cordata* and *Acer mono* (Lim et al., 2003). I treated species richness of each year as replication, hypothesized that the two areas have no public access and low pressure of human disturbance during previous 10 years because they had been designated as conservation regions. F-test was applied to show the differences of number of species and individuals between two regions.

Foraging behavior, foraging location and tree preference

I recorded the number of foraging behavior of tits per minute (Altmann, 1974). Each observation bout of an individual bird was consisted of 30-40 observations. The foraging behavior of birds was recorded by using binoculars (8×30) between 0700 and 1200 during breeding periods (mid April to mid July) from 1995 to 1997. To avoid bias from repeated observations of the same individuals, I collected data while walking steadily within the study area. I walked along alternate, numbered lines in the long dimensions of the grid. Each time a bird was observed to attack a prey item, I recorded the part of foraging, the maneuver of attack, the foraging location, the foraging height and the plant species to which the attack was directed. The data on fledglings were excluded from the analysis. A foraging bird was followed for as long as I could keep it in sight (Holmes and Schultz, 1986). I also differentiated three types of feeding technique (gleaning, pecking, or hovering; Remsen and Robinson, 1990). I designated each feeding technique as follows; gleaning is picking food items from a nearby substrate without full extension of legs or neck, no acrobatic movements are involved. Hovering (sally-hovering) is flying from a perch to attack a food item. Pecking is driving the bill against the substrate to remove some of the exterior of the substrate. Foraging locations were classified into air, bud, leaf, branch, trunk and ground. Only the first tree species used by a bird in a foraging observation was used in the analyses of tree species preference, because observations of additional trees in the same foraging bout may not be independent from the initial tree (Bell et al., 1990). Tree species preference was calculated with $\ln(r_i/p_i)$, where r_i was the proportion used by birds and p_i was the IV/100 for each tree species i. Chi-square tests with bonferroni options were conducted to reveal inter-specific differences in tree species use, foraging location and foraging maneuver.

RESULTS

The species numbers of breeding birds were 25, 24 and 22 in 1995, 1996, and 2004, respectively. The dominant species were *Erithacus cyane*, *Parus palustris*, and *Parus ater* at study area. In 2004, we did not observe any individual of *Certhia familiaris*, *Muscicapa latirostris*, and *Aegithalos caudatus* that had been observed in 1995 and 1996 (Table 1).

The number of species did not differ, but the number of individuals did significantly differ, and guild composition significantly differed among nesting guilds between Gwangneung and Mt. Jumbongsan areas. The number of species and individuals of bush nesters were significantly higher at Mt. Jumbongsan than Gwangneung ($P<0.05$, Table 2). Four birds showed significant inter-specific differences in use of foraging location. *P. varius* highly utilized leaves, grounds and buds, *P. palustris* buds and leaves, and *P. ater* highly used branches, leaves and buds. But, Nuthatch (*Sitta europaea*) used trunk and ground parts more (Fig. 1, Table 3). The three tits did not show significant inter-specific differences in use of foraging maneuver: they preferred gleaning and hovering maneuver. However, Nuthatch utilized the gleaning and pecking maneuvers (Fig. 2, Table 3). The three tits did not show significant inter-specific differences in use of foraging tree, and highly foraged prey in *Prunus sargentii*. However, they showed significant inter-specific difference with *Sitta europaea,* which preferred the *Quercus mongolica*, *Acer pseudosieboldianum* and *Acer mono* (Tables 3, 4). With the exception of Nuthatch

Table 1. Number of breeding birds at study area in Mt. Jumbongsan

Species	Guild		′95	′96	′04
	Nesting[1]	Foraging[2]			
Erithacus cyane	B	b	8	6	4
Phylloscopus borealis	B	b	2	4	4
P. occipitalis	B	b	6	4	3
Troglodytes troglodytes	B	b	6	4	4
Bonasa bonasia	B	b	2	1	1
Emberiza elegans	B	b	2	3	3
Parus varius	H	c	4	3	4
P. palustris	H	c	4	6	5
P. ater	H	c	4	6	5
Sitta europaea	H	c	4	5	4
Picus canus	H	c	1	1	1
Dendrocopos major	H	c	2	2	1
D. leucotos	H	c	1		1
D. kizuki	H	c	2	2	2
Certhia familiaris	H	c	2	2	
Muscicapa latirostris	C	c	4	4	
Aegithalos caudatus	C	c	2	4	
Garrulus glandarius	C	c	2	1	2
Corvus corone	C	c	1	1	1
Turdus pallidus	C	b	2	3	2
Streptopelia orientalis	C	b	2	3	2
Phylloscopus inornatus	*[3]	*	+[4]	+	+
Emberiza tristrami	*	*	+		+
Strix uralensis	*	*	4	1	1
Cuculus saturatus	*	*	1	1	1
Species richness			25	24	22
Number of individuals			68	67	51
Density (ea/ha)			9.1	8.9	6.8

[1]Nesting guild: H-hole, B-bush, C-canopy, [2]Foraging guild: b-bush and ground, c-canopy and air, [3]Characteristics of guilds were difficult to classify due to pecularity of breeding habit, [4]These birds were observed but had no territories.

(X^2 = 6.24, p=0.29), the tits were selective in their choice of foraging trees (*P. varius*, X^2=42.20, p<.0001; *P. palustris*, X^2=78.68, p<.0001; *P. ater*, X^2=46.61, p<.0001, Table 4). Nuthatch preferred twelve species among 15 trees, and utilized *Ulmus laciniatta* and *Acer mono* less than expected, and *Fraxinus mandschurica* and *Quercus mongolica* more than expected (Fig. 3). Varied tits (*Parus varius*) avoided seven, but preferred eight species of trees.

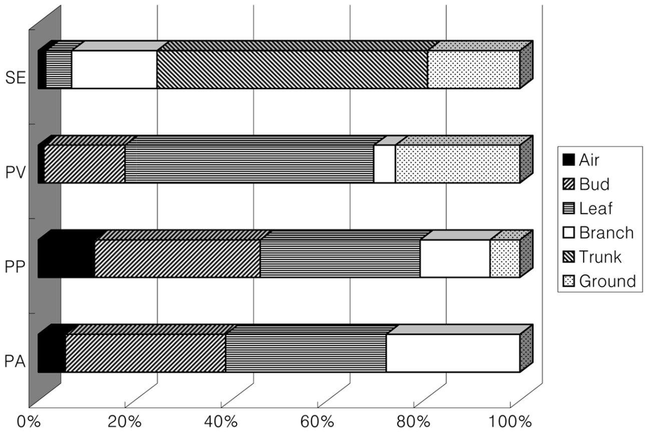

Fig. 1. Percentage use of foraging location by four birds (SE: *Sitta europaea* (n=138), PV: *Parus varius* (n=89), PP: *Parus palustris* (n=241), PA: *Parus ater* (n=112)).

This bird highly utilized *Prunus sargentii*, *Tilia amurensis*, and *Quercus mongolica*, but did not use *Carpinus cordata*, *Fraxinus mandschurica* and *Kalopanax pictus* (Fig. 4). Marsh tits (*Parus palustris*) avoided one tree species (*Acer triflorum*), but preferred the other trees and highly utilized *Prunus sargentii*, *Acer mono*, *Tilia amurensis*, *Ulmus laciniatta*, *Betula costata* and *Quercus mongolica* (Fig. 5). Coal tits (*Parus ater*) avoided two tree species, *Acer mono* and *Ulmus laciniatta*, but preferred the other trees and highly utilized *Quercus mongolica*, *Fraxinus mandschurica*, *Carpinus cordata*, and *Tilia amurensis* (Fig. 6).

DISCUSSION

A high elevation area can have a low biomass of insect larvae (Janes, 1994), and this may decrease the density of breeding birds. Relative high density of bush-nesters can be ascribed to the strong winds and various nesting cover at rocky block field in valley areas. In comparison with Gwangneung areas, this study area showed a low value of

Table 2. Comparison of species composition of nesting guilds between Gwangneung and Mt. Jumbongsan

No. of species and individuals	Nesting guild	Mt. Jumbongsan				Gwangneung[1]				Statistics	*P*-value
		'95	'96	'04	Mean±SD	'94	'95	'04	Mean±SD		
Number of species	Hole	9	8	8	8.33±0.58	10	10	10	10.00± 0.00	$F_{(5, 12)}$ = 19.89	<.0001
	Canopy	6	6	4	5.33±1.15	5	6	3	4.67± 1.53	Location	0.7862
	Bush	6	6	6	6.00±0.00	4	5	5	4.67± 0.58	Guild	<.0001
										Location×Guild	0.0242
Number of individuals	Hole	24	27	23	25.67±5.51	51	82	64	65.67±15.57	$F_{(5, 12)}$ = 16.42	<.0001
	Canopy	13	16	7	10.00±3.61	10	15	10	11.67± 2.89	Location	0.0038
	Bush	30	22	19	30.67±3.06	16	24	38	26.00±11.14	Guild	<.0001
										Location×Guild	0.0018
Number of species		21	20	18	19.67±1.53	19	21	18	19.33± 1.53	t = 0.80	ns
Number of individuals		67	65	49	60.33±9.87	77	121	112	103.33±23.25	t = 2.95	<0.05

[1]Data in 1994 and 1995 was from Kim et al. (1996)

Table 3. Interactions of foraging location, manuever and tree among four birds

Interactions	Foraing location			Foraging maneuver			Foraging tree		
	df	χ^2	P	df	χ^2	P	df	χ^2	P
SE-PV[1]	5	127.27	<.0001	2	32.21	<.0001	4	42.56	<.0001
SE-PP	5	232.36	<.0001	2	63.25	<.0001	4	49.37	<.0001
SE-PA	5	155.78	<.0001	2	38.41	<.0001	4	48.89	<.0001
PV-PP	4	47.99	<.0001	1	0.9	0.34 ns[2]	4	7.07	0.13 ns
PV-PA	4	55	<.0001	1	0.02	0.89 ns	4	11.19	0.02 ns
PP-PA	4	16.6	0.0023	1	0.75	0.39 ns	4	4.08	0.4 ns

[1]SE: *Sitta europaea*, PV: *Parus varius*, PP: *P. palustris*, PA: *P. ater*, [2]ns: no significant by χ^2 test with Bonferroni's correction

foliage volume at shrub layer below two meters (Kim et al., 1996, Lee et al., 1997), is covered with rocky block field due to geological process at high-elevation area in mountain. Bush and ground nesters (e.g. *Troglodytes troglodytes* and *Erithacus cyane*) easily found their nests on grounds and roots parts suitable for nesting under the rocky block field. Therefore, high density of bush-nesters (including ground nesters) characterizes the breeding bird community at high-elevation area. Although three tits did not show inter-specific difference in use of foraging maneuvers and trees, four birds showed significant difference in use of foraging location (Table 3). The bark forager Nuthatch significantly and differently utilized foraging locations, maneuvers and trees in inter-specific use with tits. Moreover, Nuthatch highly utilized the abundant trees in study area, but the other tits utilized specific trees that were convenient for them to forage prey. These results suggest that the three tits can distinguish microhabitat factor such as foraging location in selecting the tree, but nuthatch visit the bark and branch of any tree to capture prey. Therefore, microhabitat factors such as foraging location (e.g. bud, leaf, twig, branch and trunk), which can be determined by foliage structure and arrangement (Holmes and Schultz, 1986; Whelan, 2001), may be important in tree species preference among canopy-dwelling tits. Three tits showed morphological differences such as relative tarsus length and body weight among them (Park, 2001). So, accessibility of foraging location can be mutually determined by the factor of leaf arrangement and morphological traits of birds. Actually, Marsh tits and Coal tits prefer the *Abies nephrolepis* that shows dense distribution of foliage convenient for small birds. However, *P. varius* avoided trees with flat leaf arrangement such as *Carpinus cordata*, *Kalopanax pictus*, *Fraxinus mandschurica*, and *Ulmus laciniatta*, that may require hovering or sally behavior in capturing a prey (Greenberg and Gradwohl, 1980; Holmes and Schultz, 1988; Whelan, 2001). However, Varied tits preferred mixed-type leaf arrangements such as *Prunus sargentii*, *Tilia amurensis* and *Quercus mongolica* (Table 4, Fig. 4). Therefore, canopy-dwelling birds may

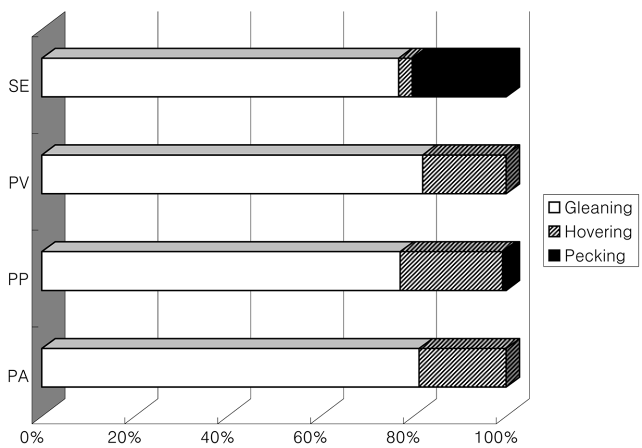

Fig. 2. Percentage use of foraging maneuver by four birds (SE: *Sitta europaea* (n=138), PV: *Parus varius* (n=89), PP: *P. palustris* (n=241), PA: *P. ater* (n=112)).

Table 4. Chi-square test between perecents observed value and imporatnce values of trees

Trees	IV[a]	SE[b]	PV	PP	PA
Quercus mongolica	21.2	29(27.6)[c]	7(10.6)	16(7.1)	3(2.7)
Acer pseudosieboldianum	15.2	4(3.8)	4(6.1)	18(8)	3(2.7)
Carpinus cordata	9.9	10(9.5)	(0)	5(2.2)	(0)
Tilia amurensis	7.8	8(7.6)	13(19.7)	22(9.7)	6(5.4)
Acer mono	6.6	(0)	4(6.1)	29(12.8)	16(14.3)
Fraxinus mandschurica	5.3	17(16.2)	(0)	4(1.8)	(0)
Kalopanax pictus	4.9	6(5.7)	(0)	10(4.4)	5(4.5)
Fraxinus ryhnchophylla	4.6	3(2.9)	4(6.1)	5(2.2)	6(5.4)
Ulmus laciniata	4.0	(0)	(0)	22(9.7)	4(3.6)
Acer triflorum	2.6	6(5.7)	(0)	(0)	10(8.9)
Abies nephrolepis	2.2	6(5.7)	(0)	3(1.3)	9(8)
Cornus controversa	1.5	4(3.8)	(0)	7(3.1)	8(7.1)
Prunus sargentii	1.5	5(4.8)	31(47)	57(25.2)	24(21.4)
Actinidia arguta	0.5	(0)	2(3)	(0)	(0)
Betula costata	0.4	(0)	(0)	15(6.6)	8(7.1)
Others	16.8	7(6.7)	1(1.5)	13(5.8)	10(8.9)
N[d]		105	66	226	112
X^2		6.24	42.2	78.68	46.61
P-value		0.29	<.0001	<.0001	<.0001

[a]Importance values of trees (data from Cho and Lee, 2001), [b]SE-*Sitta europaea*, PV-*Parus varius*, PP-*Parus palustris*, PA-*Parus ater*, [c]Values in parenthesis indicate percentage use of each tree, [d]These value exclude number of use at ground and fallen log by birds.

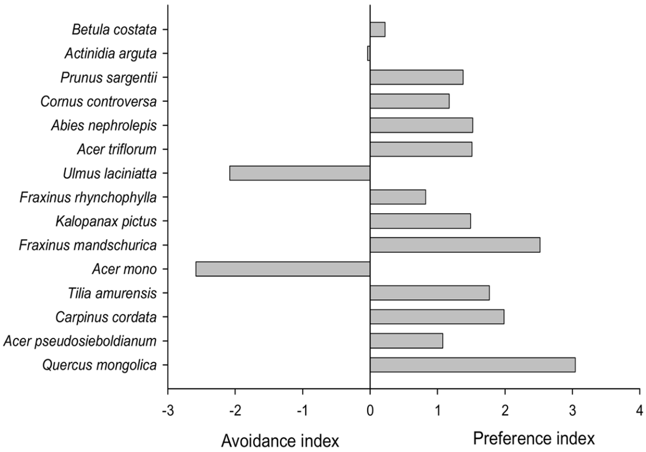

Fig. 3. Tree-species preference and avoidance for the *Sitta europaea*. Positive values indicate usage greater than expected; negative values indicate usage less than expected.

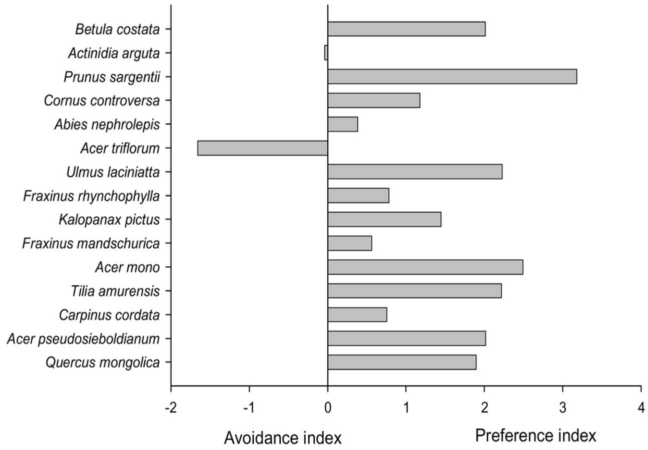

Fig. 5. Tree-species preference and avoidance for the *Parus palustris*. Positive values indicate usage greater than expected; negative values indicate usage less than expected.

detect the microhabitat of each tree. The leaf gleaners tits selectively utilized the tree species compared to the composition of trees, but the bark foragers Nuthatch did not select the tree use, but utilized the dominant tree species. Tits searched the suitable place for their morphological traits and feeding habits of each bird. Meanwhile, three tits can coexist by using different sized insect larvae (Mizutani and Hijii, 2002; Park, 2001). I did not measure prey abundance data of each tree species and had no quantitative data on foliage structure, but my data showed tree species preference of birds in the study area. So, it is needed to quantify the foliage structure by three-dimensional digitizer, and to gather annual data on the prey abundance at each part (upper and lower) of leaf. In conclusion, I suggest that morphological traits of birds and tree characteristics such as microhabitat of leaf arrangement can be important in tree species preference among canopy-dwelling birds.

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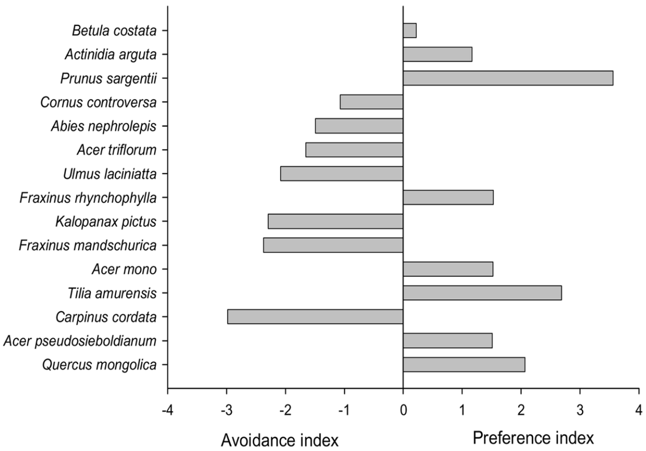

Fig. 4. Tree-species preference and avoidance for the *Parus varius*. Positive values indicate usage greater than expected; negative values indicate usage less than expected.

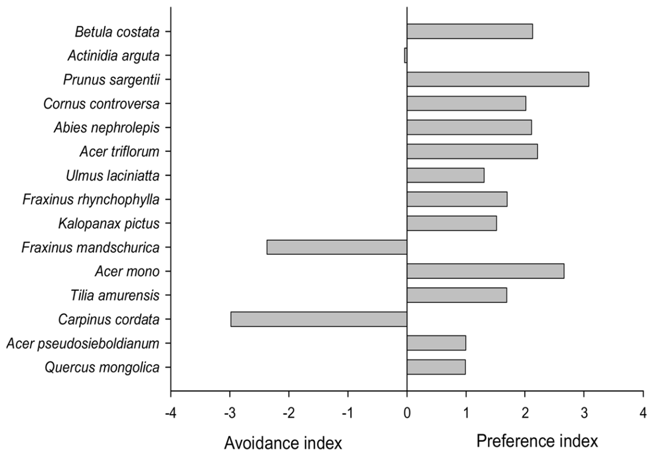

Fig. 6. Tree-species preference and avoidance for the *Parus ater*. Positive values indicate usage greater than expected; negative values indicate usage less than expected.

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