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Abundance and Distribution of Birds in Four, High Elevation Plant Communities in Yushan National Park, Taiwan

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Abstract

The bird communities of four high elevation plant communities were studied at Tatchia, Yushan National Park, Taiwan. The plant communities included a mature primary spruce forest and three seral stages of secondary vegetation that grow after a fire, grassland, pine woodland and mixed coniferous forest. The densities of all 30 bird species found in the four plant communities were estimated by the circular-plot method in July and August, 1990. Each community at different sites shows distinct pattern in species composition, guild structure and bird density. Most species show preference in habitat selection. The avian community parameters roughly followed the succession pattern. Total number of species and total density increase along the succession gradient. The bird community in spruce forest had the highest Shannon diversity index, followed by pine woodland, mixed coniferous forest, and grassland. Evenness indices were highest in pine woodland and grassland, and lowest in mixed coniferous forest and spruce forest. The Bray-Curtis index of similarity between two bird communities decreased as the successional difference between plant communities increased. The bird communities in pine woodland and mixed coniferous forest, intermediate successional stages, had the highest index of similarity (0.55), while the bird communities, grassland and spruce forest, the extreme ends of pyroseres, were least similar (0.25). In this study habitat selection by birds was largely a function of habitat structure and bird foraging methods.

Key words: Bird community, succession, circular-plot method, forest fire

INTRODUCTION

Although there have been several reports on bird distribution in Taiwan (see Lee *et al.*, 1996), there have been few studies of bird community pattern. This is due partly to the lack of life history information for most resident species and partly to the lack of attention to community level study in Taiwan.

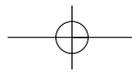
Succession is characterized by clear changes in species composition, diversity and life form (Rosenzweig, 1995). There have been many studies focusing on succession in plant communities in Taiwan (e.g., Kuo, 1988). The

study of the animal communities adapted to various seral stages is more difficult, due to great mobility and a general lack of knowledge about the taxonomy and life histories of mammals and birds (Johnston and Odum, 1956). Birds provide excellent opportunities for studies of animal adaptation to various stages of succession because of their overt and observable behavior, and relatively strict habitat requirements.

Forest fire is one of the disturbances that controls the distribution of plant communities in the high mountain areas of Taiwan (Lin, 1994). In the *Tsuga-Picea* zone, between 2500

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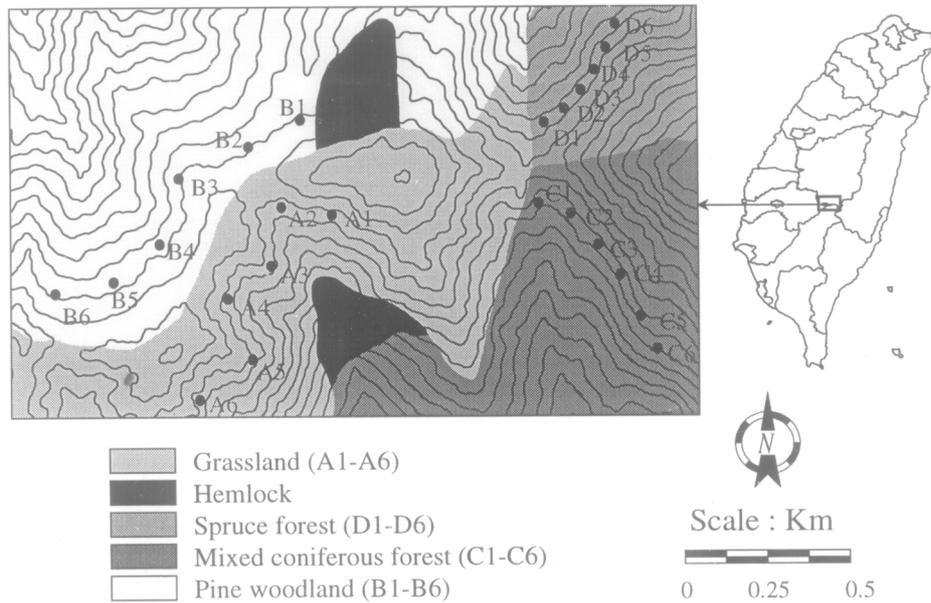


Figure 1 A location map of the bird sampling points in four plant communities at Tatchia, Yushan National Park, Taiwan.

m and 3000 m elevation in central Taiwan, the climax vegetation consists of mature primary forests of hemlock (*Tsuga chinensis*) or spruce (*Picea morrisonicola*) (Su, 1984). Forest fires usually take place on south-facing slopes and destroy almost all the vegetation (Lin, 1994). After fires, grasslands of *Yushania niitakayamensis* and *Miscanthus transmorrisonensis* prevail. If there are no additional disturbance, grassland is replaced by pine woodland dominated by *Pinus taiwanensis* and *P. armadii* or mixed coniferous forest composed of *P. taiwanensis* and *Picea morrisonicola*. Eventually mature forests of hemlock or spruce develop. Frequent fires disrupt succession, maintain early and mid-successional plant communities (Liu and Su, 1978) and create a diversified landscape. These landscapes can occur in a local and limited area and provide an ideal opportunity to study bird communities associated with different stages of plant succession.

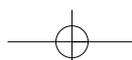
The general hypothesis tested was that differences in the structure and composition of vegetation in different seral stages influenced the structure of avian communities and the

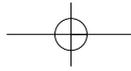
densities of some bird populations by altering the quantity and quality of habitat suitable for foraging and nesting. Specifically, we studied and compared the structure and organization of bird communities in four pyroseres (grassland, pine woodland, mixed coniferous forest, and spruce forest) in the Tatchia area of Yushan National Park, central Taiwan.

Study Area

The study area was located at Tatchia (23°28'30"N, 120°53'30"E) on the western ridge of Mt. Yushan in Yushan National Park, at elevations ranging 2550 m to 2750 m (Figure 1). Monthly mean temperature ranges from 4.2 to 11°C, annual total precipitation is between 3000 and 3750 mm, and the relative humidity averages 76.9%. Most of the area has been subjected to varying degrees of forest fire and human disturbance, and the vegetation is diverse with several successional stages.

The bird communities of four plant communities, grassland, pine woodland, mixed coniferous forest and spruce forest, that represent the gradient of succession in the area, were





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studied. Kuo (1988) classified the vegetation communities into five pyrosere stages based on succession development. The grassland belongs to the second stage, pine woodland and mixed coniferous forest the third, and spruce forest the fifth.

The grassland study site was located on the ridge and south-facing slope of Mt. Luling. Grassland is the earliest stage of succession found in the study. The grasses *Miscanthus transmorrisonensis* and *Yushania niitakayamensis* form a heavy ground cover of 0.6 m in height. Except for some scattered seedling of *Pinus taiwanensis*, 0.5-2 m in height, this community lacked trees.

The pine woodland study site was located on the north-facing slope of Mt. Luling. The canopy was about 5 meters in height and was dominated by *Pinus taiwanensis* and *P. armadii*. The understory, less than 1 m in height, mainly consisted of *Yushania niitakayamensis*, *Miscanthus transmorrisonensis*, and raspberry (*Rubus* spp.). This vegetation type represents an intermediate stage of succession.

The mixed coniferous forest study site was located on the south-facing slope of Mt. Yushanchien and was dominated by *Pinus taiwanensis*, *Picea morrisonicola*, and *Juniperus formosana*. The forest was about 5 m tall, shrub and herb layers were not developed.

The spruce forest study site was located on the north-facing slope of Mt. Yushanchien. This community was typical of the climax vegetation at this elevation. The spruce forest was dominated by *Picea morrisonicola*, about 35 m tall, and had a well developed, but not widespread deciduous secondary-canopy of *Neolitsea acuminatissima* and *Litsea morrisonicola*. The shrub and herb layers were relatively complex and well developed.

METHODS

Bird Surveys

In July and early August, 1990, we conducted bird surveys using a circular plot method (Reynolds *et al.*, 1980). Twenty-four bird sampling points, six in each plant community, were

selected (Figure 1). The sampling points that were spaced approximately 120 m apart and were roughly 80 m from community edges. Bird sampling plots consisted of a circle with 70 m radius around each point.

Bird counts were conducted from sunrise to about 1030 hrs. Two researchers stopped at the sampling point in each plot in each plant community once each day for 5 minutes and recorded the number, distance, gender (appearance or song), and vocalizations (singing or not singing) of all birds seen or heard within the plot. Birds flying over plots or observed between plots were not included. The timing of the order in which points were visited was varied to diffuse sampling for a specific point across the time of day. In total, 240 bird counts were conducted.

Nomenclature of birds follows Sibley and Monroe (1990).

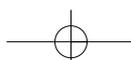
Data Analysis

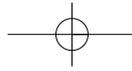
The data was entered into Microsoft Excel and the bird densities for each species in each plot were calculated by the following formula (Reynolds *et al.* 1980)

$$D = \frac{n}{\pi r^2 C} 10000$$

where D = bird density (number/ha), n = total number of birds observed within the specific basal radius, r = specific basal radius (m), and C = total number of counts conducted. The bird density data for each species were then averaged for each plant community.

The specific basal radius for each species was determined the sampling data as the distance from the sampling point at which the bird species number first began to decline. Because the detect openness of the vegetation influenced the ability of the observers to see different birds (Oelke, 1981), we separately calculated the specific basal radius for each bird species in each of the four plant communities. Density for each species in each plant community was then calculated using the total number of birds encountered within the circle of specif-



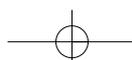


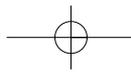
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Table 1 Bird density (number/ha) in the four plant communities at Tatchia, Yushan National Park, Taiwan. Nomenclature of birds follows Sibley and Monroe (1990).

Species name	Scientific name	Guild*	Plant community			
			Grassland	Pine woodland	Mixed coniferous forest	Spruce forest
Collared Bush-Robin	<i>Tarsiger johnstoniae</i>	GI	4.24	2.12	1.59	1.33
White-whiskered Laughing Thrush	<i>Garrulax morrisonianus</i>	GO	2.47	2.21	9.10	2.21
Streak-throated Fulvetta	<i>Alcippe cinereiceps</i>	BI	1.99	9.15	9.42	3.19
Formosan Yuhina	<i>Yuhina brunneiceps</i>	TO	1.12	2.48	8.841	2.03
Yellow-bellied Bush-Warbler	<i>Cettia acanthizoides</i>	BI	1.06	5.48	2.95	0.83
Russet Bush-Warbler	<i>Bradypterus seebohmi</i>	BI	0.77	1.65	0.47	0.41
Spotted Nutcracker	<i>Nucifraga caryocatactes</i>	BG	0.04	0.07	0.04	0.02
Vinaceous Rosefinch	<i>Carpodacus vinaceus</i>	GG	0.17	2.21	0.26	1.87
Coal Tit	<i>Parus ater</i>	TI	0.35	0.59	-	3.94
Grey-headed Bullfinch	<i>Pyrrhula erythaca</i>	TO	0.12	1.71	-	-
Green-backed Tit	<i>Parus monticolus</i>	TI	-	0.30	0.18	0.83
Large-billed Crow	<i>Corvus macrorhynchos</i>	GO	-	0.01	0.09	0.14
Flamecrest	<i>Regulus goodfellowi</i>	TI	-	1.84	-	18.56
Black-throated Parrotbill	<i>Paradoxornis nipalensis</i>	BI	-	1.60	-	-
Ashy Wood-Pigeon	<i>Columba pulchricollis</i>	TF	-	0.07	-	-
Rufous-capped Babbler	<i>Stachyris ruficeps</i>	BI	-	-	2.06	0.47
White-browed Shortwing	<i>Brachypteryx montana</i>	GI	-	-	0.96	1.09
Steere's Liocichla	<i>Liocichla steeri</i>	GO	-	-	1.83	2.18
White-eared Sibia	<i>Heterophasia auricularis</i>	TO	-	-	0.30	0.8
Pygmy Wren-Babbler	<i>Pnoepyga pusilla</i>	GI	-	-	0.10	2.05
Fire-breasted Flowerpecker	<i>Dicaeum ignipectus</i>	TI	-	-	0.06	-
Streak-breasted Scimitar-Babbler	<i>Pomatorhinus ruficollis</i>	BI	-	-	0.03	-
Brownish-flanked Bush-Warbler	<i>Cettia fortipes</i>	BI	-	-	0.02	-
Formosan Barwing	<i>Actinodura morrisoniana</i>	TO	-	-	-	2.39
Ferruginous Flycatcher	<i>Muscicapa ferruginea</i>	F	-	-	-	0.81
Rufous-faced Warbler	<i>Abroscopus albogularis</i>	F	-	-	-	0.3
Vivid Niltava	<i>Niltava vivida</i>	F	-	-	-	0.24
Wood Nuthatch	<i>Sitta europaea</i>	BG	-	-	-	0.18
Gray-cheeked Fulvetta	<i>Alcippe morrisonia</i>	BI	-	-	-	0.06
Snowy-browed Flycatcher	<i>Ficedula hyperythra</i>	F	-	-	-	0.06
Number of species			10	15	18	24
Total density			12.33	31.49	38.3	55.99
Evenness index			0.79	0.81	0.68	0.71
Shannon-Wiener diversity index			2.61	3.17	2.82	3.26

* GG = Ground graminivore, GI = Ground insectivore, GO = Ground omnivore, BI = Bush insectivore, BG = Bole gleaner, TF = Tree frugivore, TI = Tree insectivore, TO = Tree omnivore, and F = Flycatcher.





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Table 2 Total density (number of species in parentheses) and percentage of bird guilds in four plant communities at Tatchia, Yushan National Park, Taiwan.

Guild	Plant community							
	Grassland		Pine woodland		Mixed coniferous forest		Spruce forest	
	Density	%	Density	%	Density	%	Density	%
Ground graminivore	0.17 (1)	1.4	2.21 (1)	7.0	0.26 (1)	0.7	1.87 (1)	3.3
Ground insectivore	4.24 (1)	34.4	2.12 (1)	6.7	2.65 (3)	6.9	4.47 (3)	8.0
Ground omnivore	2.47 (1)	20.0	2.22 (2)	7.0	11.02 (3)	28.8	4.53 (3)	8.1
Bush insectivore	3.82 (3)	31.0	17.88 (4)	56.8	14.95 (6)	39.0	4.96 (5)	8.9
Bole gleaner	0.04 (1)	0.3	0.07 (1)	0.2	0.04 (1)	0.1	0.20 (2)	0.4
Tree frugivore	0.00	0.0	0.07 (1)	0.2	0.00	0.0	0.00	0.0
Tree insectivore	0.35 (1)	2.8	2.73 (3)	8.7	0.24 (2)	0.62	3.33 (3)	41.7
Tree omnivore	1.24 (2)	10.1	4.19 (2)	13.3	9.14 (2)	23.9	15.22 (3)	27.2
Flycatcher	0.00	0.0	0.00	0.0	0.00	0.0	1.41 (4)	2.5

ic basal radius. Except for the Large-bellied Crow and the Spotted Nutcracker who had a specific basal radius of 70 m, the specific basal radius for the other species was no more than 60 m.

To characterize the bird community in each plant community, we calculated the Shannon-Wiener diversity index and an evenness index (Krebs, 1989). We calculated the Bray-Curtis measure of similarity (Krebs, 1989) to compare the distribution patterns of bird species across the four plant communities and to compare community structure and functional groups. Bird species were regrouped into nine guilds: ground graminivore, ground insectivore, ground omnivore, bush insectivore, bole gleaner, tree frugivore, tree insectivore, tree omnivore, and flycatcher (Ding, 1993).

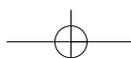
RESULTS

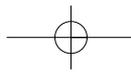
In total, 30 species of birds were recorded in the four plant communities at Tatchia (Table 1). The Formosan Yuhina was the most common and abundant species, accounting for 17.7% of total bird density, followed by the Streak-throated Fulvetta (17.2%) and the Flamecrest (14.8%). Ten species were found in the grassland where the Collared Bush-Robin was the dominant species (Table 1). Of the 15

species that occurred in pine woodland, the Streak-throated Fulvetta and the Yellow-bellied Bush-Warbler were most abundant while the Black-throated Parrotbill and the Ashy Wood-Pigeon occurred only in this plant community. All of the species that occurred in the grassland also occurred in pine woodland.

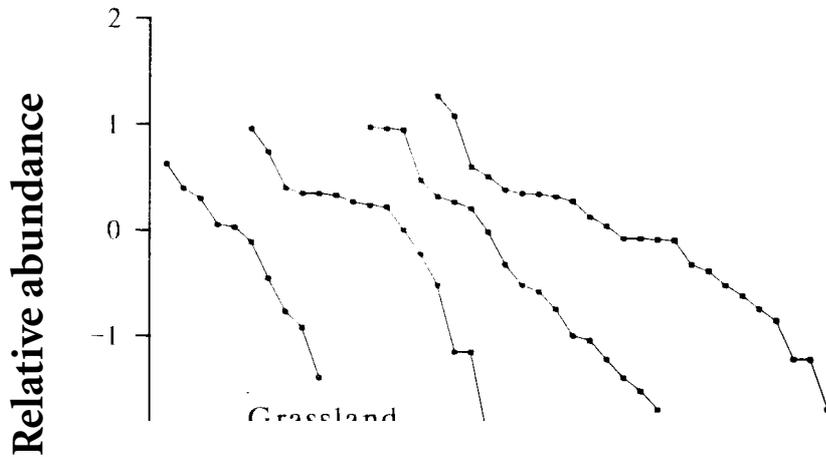
Among the 18 species that occurred in the mixed coniferous forest, the White-whiskered Laughing Thrush, the Streak-throated Fulvetta, and the Formosan Yuhina were dominant. Three species typical of deciduous forest, the Fire-breasted Flower Pecker, Streak-breasted Scimitar-Babbler, and Brownish-flanked Bush-Warbler occurred only in this plant community, where they were near their upper elevational limit.

Of the four plant communities, the spruce forest had the largest number of bird species. It supported two general groups of bird species occurred in all plant communities and those confined to the climax forest. With 24 species, the spruce forest contained more species of birds than the other three plant communities combined. The Formosan Yuhina and Flamecrest were dominant. Although eight wide ranging species were present, there were seven species, the Formosan Barwing, Ferruginous Flycatcher, Rufous-faced Warbler,





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Species rank

Figure 2 Species rank curve for the four avian communities in the Tatachia area of Yushan National Park, central Taiwan. The curve for the grassland bird community is close to a geometric curve and the curve for the spruce forest bird community is close to a log-normal distribution. The others fall between these two extremes.

Vivid Niltava, Wood Nuthatch, Gray-cheeked Fulvetta, and Snowy-browed Flycatcher, that occurred only in the climax spruce forest.

In general, the bird species in this study fell into two groups: those that occurred in only one or two plant communities and those that occurred in all four. Wide ranging species included the Collared Bush-Robin, the White-whiskered Laughing Thrush, the Streak-throated Fulvetta, the Formosan Yuhina, the Yellow-bellied Bush-Warbler, the Russet Bush-Warbler, the Spotted Nutcracker, and the Vinaceous Rosefinch. In any given plant community, bird species that were restricted to one or two plant communities were usually less abundant than the wide ranging bird species, but the Flamecrest was an exception.

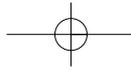
The bird communities in the four plant communities differed in their guild structure (Table 2). Ground insectivores and bush insectivores were dominant in the grassland, while bush insectivores were dominant in the pine woodland. In the mixed coniferous forest,

ground omnivores, bush insectivores and tree omnivores were abundant, while tree insectivores and tree omnivores were the most common guilds in the spruce forest. Flycatchers (four species) occurred only in the spruce forest, while the only tree frugivore (one species) was found in the pine woodland.

The total number of bird species and total bird density increased along the successional gradient (Table 1). Evenness was higher in pine woodland and grassland, and lower in mixed coniferous forest and spruce forest. Diversity was highest in spruce forest, followed by pine woodland, mixed coniferous forest, and grassland.

Species abundance curves are another way to characterize community patterns (Figure 2). The curve for the grassland bird community is close to a geometric distribution, while the curve for the spruce forest bird community approximates a log-normal distribution. The curves for the pine woodland and mixed coniferous forest fall between these two extremes.





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Table 3 Bray-Curtis index of similarity for bird communities in four plant communities at Tatachia, Yushan National Park, Taiwan

Plant community	Grassland	Pine woodland	Mixed coniferous forest	Spruce forest
Grassland	-			
Pine woodland	0.45	-		
Mixed coniferous forest	0.35	0.55	-	
Spruce forest	0.25	0.35	0.45	-

The bird communities in successive stages of the pyrosere were more similar in species composition than bird communities in non-successive stages (Table 3). The bird communities in the intermediate successional stages (pine woodland and mixed coniferous forest) were most similar (0.55), while the bird communities in the plant communities at the extreme ends of the pyrosere (grassland and spruce forest) were least similar (0.25).

DISCUSSION

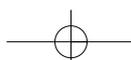
Habitat selection by forest birds is largely a function of habitat structure and the foraging method of the birds. Tokeshi (1993) found that the structure of plant communities had a great influence on the distribution of bird species. In this study the species richness and composition of the bird communities was influenced by the vertical structure of the plant communities. Individual bird species may cue on specific structural features for foraging, predator avoidance, and nesting (Tomoff, 1974; Holms and Robinson, 1981; Cody, 1985). The dependence of birds on vegetation and its effect on determining the diversity of feeding, breeding, and hiding possibilities for birds has been documented in numerous studies (Odum, 1950; Johnston and Odum, 1956; Emlen, 1970; Shugart and James, 1973; Blake, 1982).

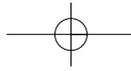
A general increase in bird species richness and diversity through progressive successional communities, with more resource specialists in the later seral stages, was evident in our study. Bird population densities tended to increase with the successional stage of the plant com-

munity. Many researchers have documented similar findings (see Shugart and James, 1973, for summary) in diverse regions, both deciduous and coniferous climax forests. This gradual increase in richness and density is associated with increases in foliage height diversity (MacArthur and MacArthur, 1961), tree height (Cody, 1985) and vertical stratification. However, Kendeigh (1946) found that the highest bird densities in the deciduous-coniferous forest ecotone occurred in the shrubby seral stage rather than in the climax forest. Karr (1968) also noted a decline in bird species and density in a climax forest.

The availability of vertical habitat can greatly influence the occurrence and density of bird species. The fire at Tatachia influenced the distribution and abundance of birds by changing the structure and composition of the vegetation. In January 1993, a forest fire occurred at Tatachia close to our study sites (Lin, 1994). We conducted a preliminary survey of the avian community in January, a few days after the fire and later in April and May of 1993 (Ding and Lee, unpublished data). In the burned area, we found only Large-billed Crow, Formosan Yuhina, and Formosan Laughing Thrush. The bird community in the partially burned area was very similar to those found in the grassland and pine woodland, but the bird densities were lower.

The spruce forest had 80% of the bird species found in this study and most of the species appeared to be closely associated with the spruce forest for food or nest sites. The spruce forest was the most structurally complex plant community at this elevation and





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provide a diverse microhabitats important to most of the bird species found in the Tatchia area. Except for some generalists and species at the vertical limit of their distribution, most species reached their peak densities in the spruce forest.

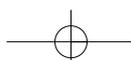
Although this survey was conducted late in the breeding season (July and August), the data obtained in this study well represented the spruce forest bird community. We compared data from the bird community in the spruce forest with a similar data set collected in the same forest type in adjacent areas between May and June 1992, at the peak of the breeding season (Ding 1993). The results of the two studies were similar in terms of species composition, dominant species, and density, but Ding (1993) found six more species, all had density estimated less than 1.0 per ha.

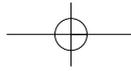
ACKNOWLEDGMENTS

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