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RESEARCH ARTICLE

# Role of magpie in bird community formation in secondary forest

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**Abstract** We analyzed a bird community in a secondary forest and the results show that the magpie was one of the key groups in the secondary forest. The key group is identified based on the nests used by other birds at a rate of 25%–40.17%. The size of the community is different and the number of these key groups is not certain.

**Keywords** key group, bird community, secondary forest, magpie

## 1 Introduction

Many contemporary community ecologists believe that the central issue in a community ecology is how the community aggregation forms (Connel, 1978). To date, ecologists can only explain part of the community structure, such as species packing and community subsets which are formed by species interactions including predation, competition, the mutually beneficial paragenesis, the food web, and so on. The body of research in island biogeography believes that the mechanism forming the stable island community is dynamically in equilibrium based on immigrant and emigrant rate. Recently, disturbance and spatial heterogeneity are regarded as the main factors for gathering more species in the community (Gao, 1991). Scientists have made numerous research on the overall population structure, for example, competition (Macarthur and Wilson, 1991), disturbance (Paine, 1969), resource partition (Pimm, 1982), predation (Paine, 1966) and island-biogeography theory (Pimm et al., 1991) etc.

Although an experiment may be allowed to prove the key species role (Krebs, 1994), such an experiment is not usually practical and ideal, because it is not clear whether all the resources in the habitat have been used (Kathy Martin, 2004). We believe that the community structure in the secondary deciduous forest is formed due to key groups, such as the primary cavity nesting birds and magpies. In this paper, we intensively analyzed the function and role that the Key Group play in a bird community structure during 5 consecutive breeding seasons in the same sample area (Sunru, 2001; Wang and Gao, 2002; Wang and Gao, 2003). We attempted to explain the central question of bird community ecology.

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## 2 Study area and methods

### 2.1 Study area

The study area (126°–126°04′E, 43°07′–44°06′N) is located in the secondary forest of Zuojia Nature Reserve in Jilin Province, China. The total area of the protected region is 42 km$^2$, with an elevation 240–460 m. In this forest the age of the arbors are between 50 and 70 years old. There are more than 40 families and more than 300 species of plants in this protected region. Among these are 14 species of arbors. The average diameter at breast height (dbh) of the arbor trees is 48.81 $\pm$ 4.78 cm. The average tree height of the arbor trees is 12.28 $\pm$ 2.33 m. The average crown height is 6.31 $\pm$ 2.37 m. The average crown area is 34.48 $\pm$ 24.72 m$^2$ and the tree coverage is 9414.07 m$^2$.

### 2.2 Methods

We chose a 39.8 hm$^2$ area to study. The investigation method of vegetation was as follows: In the sample area, we stochastically chose a standard tree and took the standard tree as the baseline, recorded tree species, tree

diameter at breast height, the tree heights, the crown heights, the tree coverage, etc., in a 30-m radius. Among these, the crown coverage used the long-axis crown and the short-axis crown as variables and the crown total area was obtained according to the ellipse area.

New and old nest investigation: From 2000, we marked the magpie nests yearly and recorded the number of new nests and old nests. We recorded the new nest increase rate and the old nest reutilization.

The method of investigation of the birds' community structure was by locating all the bird nests every year in the sample area and recording the species, the quantity and distribution of the nests. Calculation of the species diversity and the similarity was done by using the Shannon-Wiener (1949) diversity index ($H'$) formula and the Whittaker (1960) similar index ($I$) formula, respectively.

## 3 Results

### 3.1 Bird community structure in secondary forest

#### 3.1.1 Bird community structure

We investigated the bird nest species and the quantity from May to June of 2000 to 2004 (bird reproduction period) at the sample area. The results are shown in Table 1.

Table 1 shows that different birds in different years build different nest quantities. The highest year was in 2002 and in 2003, respectively, for 77 nests and 79 nests. In 5 years, there were 17 different kinds of birds that built nests, among which the most was the magpie, whose average was over 10 nests every year, followed by the Great Tit and the Black-naped Oriole.

#### 3.1.2 Bird species diversity

We calculated species diversity by using the Shannon-Wiener diversity index ($H'$) for the 5-year period (Table 2).

Bird species diversity was the highest in 2004 ($H' = 2.67$). It was similar in 2000 and 2002, and in 2001 and 2003. We can see that bird diversity highs and lows and the general trend change was a year more or less.

#### 3.1.3 Bird similarity between years

The bird similarity between years was computed using the Whittaker formula (1960) (Table 3).

From Table 3, we could see that the bird similarity index between different years, 2002 and 2003 to be more specific, were very similar ($I = 1.0$). The next closest was in 2003 and in 2004 ($H' = 0.9697$).

### 3.2 The mechanism of the birds' community structure

According to our years of observation, we found the key group, which provided nest site resources and played a very important role, was defined as the species which had a high influence on the formation of the bird community structure and community patterns in a secondary forest. Magpies were the key group in forming the bird community structure.

Magpies build new nests and use old nests in the 39.8 hectares sample areas every year (including those used by other kinds of birds) (Table 4, 5).

Obviously, the highest utilization of the new and old magpie nests was 40.7% and the lowest was 25%. Table 4 also shows that majority of the total number of nests used (new and old) were old magpie nests and the

**Table 1** Bird nest quantity and species from 2000 to 2004 (unit: nest)

| species | 2000 (14) | 2001 (12) | 2002 (16) | 2003 (16) | 2004 (17) |
|---|---|---|---|---|---|
| Red-legged Falcon (*Falcosubbuteo*) | 2 | 1 | 3 | 3 | 3 |
| Long-eared Owl (*Asio otus*) | 4 | 3 | 4 | 4 | 5 |
| Black-crowned Night Heron (*Nycticorax nycticorax*) | 2 | 0 | 2 | 2 | 2 |
| Eurasian Hoopoe (*Upupa epops*) | 5 | 5 | 8 | 5 | 3 |
| Great Pied Woodpecker (*Picoides major*) | 4 | 7 | 2 | 4 | 4 |
| Lesser Pied Woodpecker (*Picoides minor*) | 2 | 0 | 1 | 2 | 2 |
| Black-naped Oriole (*Oriolus chinensis*) | 8 | 0 | 7 | 8 | 7 |
| Ashy Starling (*Sturnus cineraceus*) | 2 | 1 | 3 | 3 | 2 |
| Tiger Shrike (*Lanius tigrinus*) | 2 | 1 | 0 | 0 | 2 |
| Yellow-rumped Flycatcher (*Ficedula zanthopygia*) | 8 | 2 | 11 | 5 | 2 |
| Common Magpie (*Pica pica*) | 15 | 15 | 16 | 20 | 7 |
| Eurasin Nuthatch (*Sitta europaea*) | 5 | 5 | 2 | 7 | 3 |
| Marsh Tit (*Parus palustris*) | 5 | 1 | 4 | 4 | 4 |
| Great Tit (*Parus majo)r* | 8 | 2 | 10 | 7 | 3 |
| Kestrel (*Falco tinnunculus)* | 0 | 1 | 1 | 2 | 1 |
| Hobby (*Falco subbuteo*) | 0 | 0 | 2 | 2 | 1 |
| Northern Eagle Owl (*Bubo bubo*) | 0 | 0 | 1 | 1 | 1 |
| total | 72 | 44 | 77 | 79 | 52 |

**Table 2** Birds species diversity index ($H'$) for every year

| 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|
| 2. 43 | 2. 17 | 2. 43 | 2. 14 | 2. 67 |

**Table 3** Bird similarity index between years ($I$)

| | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|
| 2000 | 0. 8333 | | | |
| 2001 | | 0. 7692 | | |
| 2002 | | | 1. 0000 | |
| 2003 | | | | 0. 9697 |

**Table 4** The number of new and old magpie nests

| year | total | new | old | u-new | u-old | total u-rate/% |
|---|---|---|---|---|---|---|
| 2000 | 15 | 8 | 7 | 2 | 4 | 40 |
| 2001 | 20 | 10 | 10 | 2 | 3 | 25 |
| 2002 | 26 | 16 | 10 | 4 | 5 | 34.6 |
| 2003 | 47 | 20 | 27 | 5 | 7 | 25.5 |
| 2004 | 27 | 7 | 20 | 2 | 9 | 40.7 |

Note: "u-": utilized.

utilization of the total number of nests was a quarter higher.

Table 5 shows that four species used the magpie nests and most of which were old magpie nests. The Long-eared Owl used the nests most often.

### 3.3 The magpie role in the formation of the community structure

The annual statistics of the newly built magpie nests and the number of the old nest in the 5-year study period are shown in Table 6.

## 4 Discussion

### 4.1 Bird community structure pattern of stability in secondary forests in the mountains

According to our 5-year study, there were a total of 17 varieties of birds seen, which ranged from 14 to17 species per year. Similarity between years was 0.7692–1.0 and there was no significant difference ($P > 0.05$), which means that the bird community structure is in dynamic stability. From Table 2, we can see that bird diversity in the study area during the 5-year period had a distinct pattern: there was a cycle of high and low diversity between years. We thought that the micro-dynamic stability of the region was necessarily related to the abundance in food resources, the use of food resources and the species distribution standard of food resources.

### 4.2 Magpie as the key group of bird community structure

Community structure is always an important part of a community study which mainly involves space-time dynamics and distribution patterns. Price (1984) proposed a new ecological theory that includes a Community Organization study which was more about community dynamic processes such as the law of succession and the formation mechanism of a community structure. The relationship among species in bird communities has always been an important content of populations and of community ecology. Scholars have put forward the competition theory, the niche theory, the interference theory and the resource partitioning theory and, later, the food network theory (Pimm, 1982; 2004), which starts from an ecosystem nutritional level to study interspecies relationships. This later led to the proposal of the key species theory (Paine, 1966; 1969). This theory has a great influence on ecology. Different scholars have different understanding of it and the general trend is from the top with carnivorous predators down to non-carnivorous predators.

Menge (1994) restricted the concept with the keystone predation and the keystone predator. He said that the existence of a species would limit the survival of another species and the limiting species was the key species. But there was strictly only one species undertaking this role. We observed the key groups of a bird community in a secondary forest in the mountains, such as the magpie, and found that they played the key role not by predation but by providing breeding grounds: a nest (a kind of resource). We labeled them as the key species group (keystone group) affecting the community organizational

**Table 5** The number and the species that utilized magpie nests

| species | 2000 | | 2001 | | 2002 | | 2003 | | 2004 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | new | old | new | old | new | old | new | old | new | old |
| Red-legged Falcon | 2 | 0 | 1 | 0 | 3 | 1 | 2 | 1 | 1 | 2 |
| Hobby | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| Kestrel | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| Long-eared Owl | 0 | 4 | 0 | 3 | 0 | 4 | 0 | 4 | 0 | 5 |
| total | 6 | | 5 | | 9 | | 12 | | 11 | |
| rate of old nest/% | 57. 1 | | 30 | | 40 | | 14. 8 | | 25 | |

**Table 6** The magpie's nest contribution rate

| year | new nest | rate of new/% | old nest |
|---|---|---|---|
| 2000 | 8 | 53 | 7 |
| 2001 | 10 | 50 | 10 |
| 2002 | 16 | 61. 5 | 10 |
| 2003 | 20 | 42. 6 | 27 |
| 2004 | 7 | 26. 0 | 20 |
| Average annual increase | 12. 2 | 46. 62 | |

structure and community structure. They influence the bird community pattern and are also the mechanism of the formation of a bird community structure. Naturally, different community structures possibly have different key groups. In the bird community structure, the number of key groups is related to the size of the community. In general, there is only one key group in unitary bird community structures. The more complicated bird community structure has two key groups or more. The differences between the key group and the key species are the following: (1) a key species mainly relates to the ecosystem nutrition. A key group relates to other resource in forming the community besides the food resource, such as nest resource utilization; (2) a key species emphasizes interaction among the species. A key group emphasizes an impact of one species' existence on the overall community structure formation; (3) the effect that a key species has is one kind of negative feedback. As the number of key species increases, the number of the controlled species will decrease. However, the key group's effect on the community structure is a positive feedback. The more the number of key group increases, the more resources will be provided and the number of species relying on the key group will increase; (4) the effect of a key species on the community is indirect through the food web. A key group has a direct effect because it provides resources and furthermore affects the formation of community structure. The key group forms the community organization structure. Our research on a secondary deciduous forest summer bird community has confirmed this.

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