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Distribution of Avian Ecological Groups from Different Water Levels Habitats During Autumn Migration Provide Way Forward to Preserve the Diversity of Birds in Reserve

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Key words
Habitat preference, Habitat type, Water level, Avian ecological groups, Autumn migration period, Zhalong nature reserve

ABSTRACT

The study was conducted to understand the relationship between ecological groups of birds, habitat water level in wetlands, and the spatial distribution of avian ecological groups in different habitat gradients. The study was carried out from August 2005 to October 2009, during autumn migration in the Zhalong Nature Reserve, China. The data were collected by using line-transect sampling, square sampling, circle sampling, grand point sampling methods and analyzed by cluster analysis and Chi-Square test. The results showed that during autumn migration (1) a total 79 bird species from 32 families and 13 orders including six avian ecological groups were observed, namely grallatores, passeres, natatores, raptatores, scansores and terrestores. (2) The passeres, grallatores and natatores were the three dominant avian ecological groups during autumn migration. The reed marsh with more than 30cm water dept (WL4) and the lake, with more than 30cm water depth (WL4), were the most preferred habitats. It was concluded that the dominant avian ecological groups preferred the reed marsh and lake with deep waters. (3) Different avian ecological groups had different preference for water levels (P<0.01) and habitat types (P<0.01). The dominant wetland vegetation's and unique geographical regions were the key factors influencing the spatial distribution of the avian ecological groups. Based on this research, the red mars and water bodies need more attention during autumn migration in order to preserve the diversity of birds in the reserve.

INTRODUCTION

In the development of China's economy, the impact on wetlands and birds living in them is increasing, and the problems of wetland area reduction, fragmentation, functional degradation and environmental quality decline are becoming more and more prominent, resulting in a significant decline in the species and number of birds. For birds, habitat is the environmental type occupied by individuals, populations or communities in a certain stage of life history, providing places for their various life activities. Previous studies on wetland habitat mainly focused on environmental factors such as topography, geomorphology, soil, vegetation type, water source, climate and vegetation factors such as plant community composition, plants' spatial structure, seasonal variations and life period (Evans *et al*., 2009; David *et al*., 2016; Xie *et al*., 2019).

However, there are few studies on habitat change due to water changes and water level types preferred by different birds. The migration period is an important stage in the life cycle of birds (Zou *et al*., 2012; Liechti *et al*., 2015). A key platform for energy supplies and rest for migratory birds is represented by stopover sites (Alan *et al*., 2013; Norevik *et al*., 2017). A complete understanding of the spatial distribution of migratory birds in wetlands

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during autumn, will help to improve the protective actions. Zhalong National Nature Reserve (Zhalong) is one of the biggest reserves with wetland area in Northeast China. Since the 1990s, the wetlands in Zhalong have registered a dynamic degradation due to water level fluctuations and unbalanced spatial distribution of water resources (Wang *et al*., 2006; Wu and Zou, 2011; Luo *et al*., 2014). These were caused by natural disturbances and human activities, including drought caused by reduced rain fall, annual wild fire during springtime, fishing in summer, reed harvest in winter and all kinds of wetland exploitation activities (Wang *et al*., 2010). In 2001, Zhalong had established a new water management control in order to provide water supplies in the dry years. By 2017, 2.585 million m^3 of water was transfused into the Zhalong Nature Reserve maintaining the marsh wetland ecosystem functional.

Studies have also shown that artificially controlled water levels changed the natural fluctuation of water levels in Shengjin Lake, resulting in a significant impact on the habitat of local wintering water birds. For example, due to excessive human influence, the water level is too high and there are few exposed grass beaches and mud beaches, so the utilization resources of local overwintering waterfowls are extremely rare (Wang *et al*., 2010). The diversity of avian communities at different water levels and with different spatial distribution have registered significant differences before and after irrigation, every year. Hence, this research studied the spatial distribution of the avian communities at different water level environments, during the autumn period, in Zhalong Nature Reserve. However, the spatial distribution of the avian communities during water level fluctuations remained constant (Liu *et al*., 2015). This study will lead not only to the improvement of bird communities habitat during autumn, but it will also serve as a scientific reference for irrigation schemes of wetland ecosystems.

MATERIALS AND METHODS

Site description

Zhalong (46°52′−47°32′N, 123°47′−124°37′E) lies at 26 km to the Southeast of Qiqihar city in Heilongjiang Province, China. In 1992, it was listed as a Ramsar "wetland of international importance" (especially as waterfowl habitat) (Wang *et al*., 2015; Zou *et al*., 2016). Proper location map with GPS readings is shown in Figure 1. The region belongs to the continental semiarid and monsoon climate. The total area of this reserve is 2100 km^2 with an average elevation of 144 m above sea level. The reed marshes cover 80%−90% of the reserve area, while Carex swamp (*Carex pseudoeuraica* (sedge) swamp and bulrush swamp), meadows, grasslands and farmlands occupy the remaining area (Wu *et al*., 2016, 2017). The wetland habitats are suitable stopovers for birds during autumn migration. Also, the reed marshes in the wetlands represent a primary economic resource for local people.

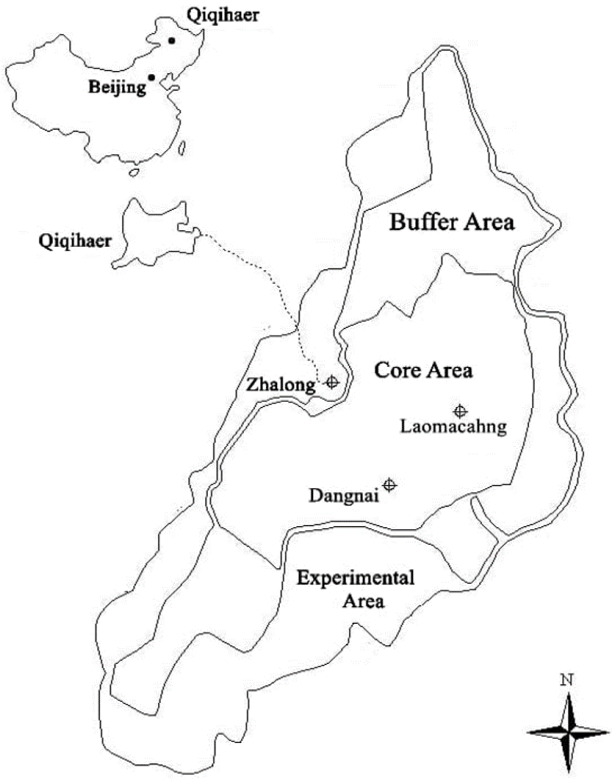

Fig. 1. Proper location map with GPS readings.

Data collection

Field investigations were carried out from August 2005 to October 2009, in Zhalong (Qiqihar city), Dangnai and Laomachang (Daqing city). By using line-transect sampling, square sampling, circle sampling, and point sampling methods, data of different bird species and their population numbers were collected from 101 sample areas in different habitat types (53 sample areas were from reed marsh area, 14 from water areas, 10 from *Carex pseudocuraica* marsh, 9 from meadows, 8 from farmlands, and 7 from open forest). Among them, the point sampling and square sampling methods were used for the investigation of bubble marshes and the use of the method was different due to the number of birds and the area and shape of the bubble marsh (square sampling method, photo and video method were used to investigate those bubble marshes with large number of birds and no statistics). Two to four observation sites were selected for each bubble and the observation time of each site was 10–15

min. The reed marsh area, *Carex pseudocuraica* (sedge) marsh, meadows and farmlands were observed by the line-transect sampling method. The length of sample line was 2 km and the unilateral width was about 100 ~ 1000 m. The actual length and unilateral width change due to the actual hydrology and observation objects. The actual survey was conducted once a month. 7-10 days each time, tried to select the same or similar monthly and sunny days for the survey. Surveyed twice a day in the morning and evening, specific observation recording times varied depending on the local sunrise time and light visibility, and in principle the local sunrise h to 9 am and 2 h before sunset were preferred (Zou *et al*., 2012) and 8x20 mm binoculars and 20-60 x 60 mm single-tube telescopes (spotting scope) were used to collect the data.

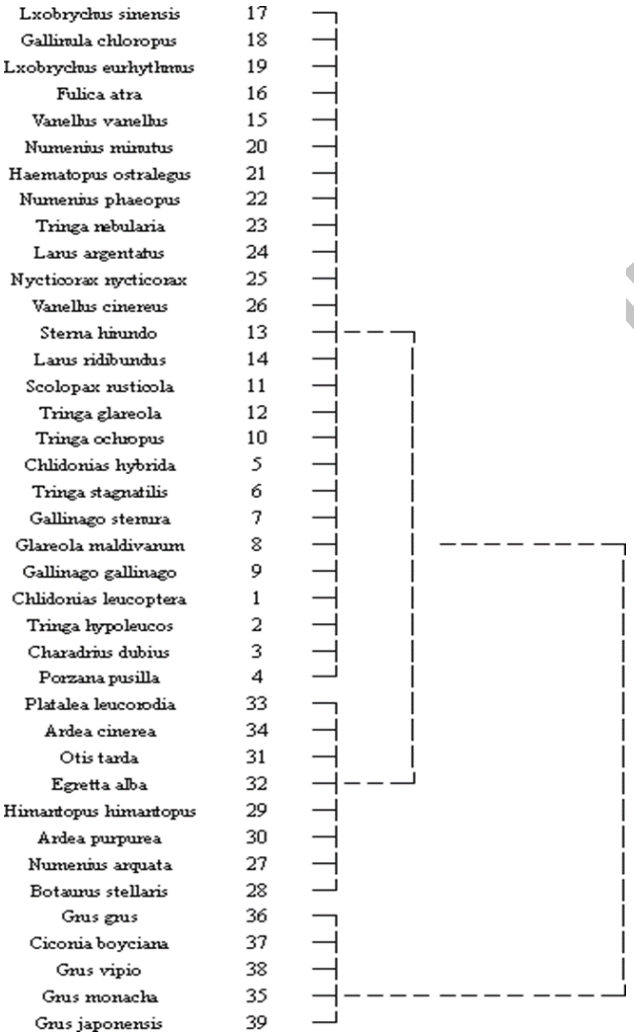

Fig. 2. Clusters of waterfowl leg length monitored at Zhalong.

Avian ecological groups

According to this research from eight avian ecological groups in the world, six of them were present in Zhalong reserve. These are natatores (N), grallatores (G), terrestores (T), raptatores (R), scansores (S) and passeres (P). The water level was defined as water depth and classified based on the clustering results of 39 waterfowl species recorded by this survey and the measurement using steel tape. Considering the leg length of all waterfowl species, three clusters were generated: 2.81-5.73 cm, 10.36-15.24 cm and 22.93-28.61 cm as shown in Figure 2 (Zou *et al*., 2012) and the maximum value was regarded as a threshold value of water level gradient. In this study, wetland environment with a water level of 0 cm was used as a specific value of water depth. The threshold values on water levels were divided into four classes, namely 0 cm, 5 cm (5.73 cm), 15 cm (15.24 cm) and 30 cm (28.61 cm). So, water levels were classified into five water level gradients, such as: 0 cm water level (no water) (WL0), 0-5 cm water level (WL1), 5-15 cm water level (WL2), 15-30 cm water level (WL3) and more than 30 cm water level (WL4), as shown in Table I.

Data analysis

The collected data were analyzed using SPSS software (version-11.5) statistical program. First, analyzed the data of different avian ecological groups monitored at different water level habitats (five water level gradients and six habitat types), by counting total numbers of avian population and density during autumn migration. Chi-square test ($\chi 2$ test) was used to analyze the correlation between the uses of different avian ecological groups of different habitat types at different water levels. Finally, it was comprehensively analyzed for habitat preference of different avian ecological groups.

RESULTS

Species component and dominant avian ecological groups

A total of 79 species of birds belonging to 32 families of 13 orders was recorded during the study period as shown in Table II, representing 41.36% of the total avian species observed at Zhalong. Figure 3 shows that species composition of six avian ecological groups was grallatores= passeres > natatores > raptatores > scansores = terrestores, representing 12.65%, while the population numbers were passeres > grallatores > natatores > raptatores > terrestores > scansores, summing, 11.24%, respectively. The passeres, grallatores, and natatores were the threemain avian ecological groups observed during autumn migration in Zhalong as shown in Figure 4, accounting for 87% as species richness and population numbers.

Table I. Leg length clusters of waterfowl species.

Cluster/ Species name	Leg length (cm) (average± SE)	Water level (cm) (Min-Max)
Cluster 1		
1.Charadrius dubius	4.27±1.46	2.81-5.73
2. Chlidonias hybrid,		
3. Chlidonias leucoptera		
4. Fulicaatra		
5. Gallinago gallinago		
6. Gallinago stenura		
7.Gallinula chloropus		
8.Glareola maldivarum		
9. Haematopus ostralegus		
10. Larus argentatus		
11. Larus ridibundus		
12. Lxobrychus eurhythmus		
13. Lxobrychus sinensis		
14. Nycticorax nycticorax		
15. Numenius minutes		
16. Numenius phaeopus		
17. Porza napusilla		
18. Scolopax rusticola,		
19. Sterna hirundo		
20. Tringa glareola		
21. Tringa hypoleucos		
22. Tringa nebularia		
23. Tringa ochropus		
24. Tringas tagnatilis		
25. Vanellus cinereus		
26. Vanellus vanellus		
Cluster 2		
1. Ardea cinerea	12.80±2.44	10.36-15.24
2. Ardea purpurea		
3. Botaurus stellaris		
4. Egretta alba		
5. Himantopus himantopus		
6. Numenius arquata		
7. Otis tarda		
8. Platalea leucorodia		
Cluster 3		
1. Ciconia boyciana	25.77±2.84	22.93-28.61
2. Grus grus		
3. Grus japonensis		
4. Grus monacha		
5. Grus vipio		

Use of different water level habitats

Chi-square test showed a significant difference ($p < 0.01$) among the uses of six avian ecological groups of different water level habitats as shown in Table III. More than 80% of passeres and terrestores population preferred habitats with no water surface (WL0) and water depth higher than 30 cm (WL4), while more than 70% of grallatores population had strongly preferred water level habitats with depths higher than 30 cm (WL4) followed by natatores (more than 90%), and only more than 3% of them preferred habitats with no water surface (WL0). More than 60% of the raptatores population preferred water level habitats with water depths higher than 30 cm (WL4) and more than 20% preferred habitats with a water depth of 15-30 cm (WL3). 100% of the scansores population preferred habitats with no water surface (WL0). All the six avian ecological groups preferred habitats with no water surface (WL0) as well as habitats with water depth higher than 30 cm (WL4); the latter was the mutual preferred habitat of the three dominant avian ecological groups.

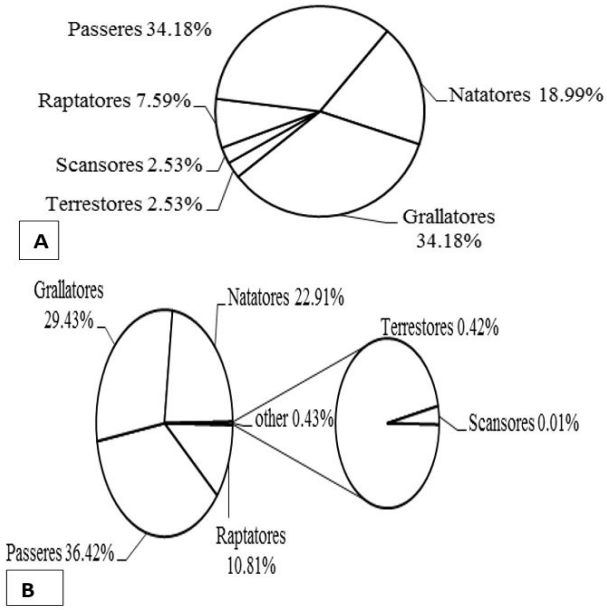

Fig. 3. Species composition (A and B) of six avian ecological groups.

Fig. 4. Geese (A) and duck (B) during autumn migration.

Table II. Species composition of the avian ecological groups.

Species	EG	Species	EG	Species	EG
ORDER1: ANSERIFORMES		**ORDER 5: CORACIFORMES**		**Family 21: Laniidae**	
Family 1: Anatidae		**Family 10: Alcedinidae**		58. *Lanius cristatus*	P
1. *Anas crecca*	N	31. *Alcedo atthis*	R	59. *Lanius excubitor*	P
2. *Anas penelope*	N	**ORDER 6: FALCONIFORMES**		60. *Laniussp henocerus*	P
3. *Anas platyrhynchos*	N	**Family 11: Accipitridae**		**Family 22: Motacillidae**	
4. *Anas poecilorhyncha*	N	32. *Buteo lagopus*	R	61. *Anthus cervinus*	P
5. *Anas strepera*	N	33. *Circus cyaneus*	R	62. *Anthus godlewskii*	P
6. *Aythya ferina*	N	34. *Circus melanoleucos*	R	63. *Anthus novaeseelandiae*	P
7. *Aythya fuligula*	N	35. *Circus spilonotus*	R	64. *Motacilla alba*	P
8. *Aix galericulata*	N	**Family 12: Falconidae**		65. *Motacilla cinerea*	P
9. *Anser albifrons*	N	36. *Falco amurensis*	R	*66. Motacilla flava*	P
10. *Anser cygnoides*	N	**ORDER 7: GALLIFORMES**		**Family 23: Paridae**	
11. *Bucephala clangula*	N	**Family 13: Phasianidae**		67. *Aegithalos caudatus*	P
12. *Cygnus cygnus*	N	37. *Phasianus colchicus*	T	**Family 24: Ploceidae**	
ORDER 2: CHARADRIIFORMES		**ORDER 8: GRUIFORMES**		68.*Passer montanus*	P
Family 2: Charadriidae		**Family 14: Gruidae**		**Family 25: Remizidae**	
13.*Vanellus cinereus*	G	38. *Grus grus*	G	69.*Remiz pendulinus*	P
14.*Vanellus vanellus*	G	39. *Grus monacha*	G	**Family 26: Sylviidae**	
Family 3: Glareolidae		40. *Grus japonensis*	G	70. *Acrocephalus bistrigiceps*	P
15.*Glareola maldivarum*	G	41. *Grus vipio*	G	71. *Acrocephalus orientalis*	P
Family 4: Haematopodidae		**Family 15: Rallidae**		72. *Locustella certhiola*	P
16. Haematopus ostralegus	G	42. *Coturnicops noveboracensis*	G	73. *Phylloscopus proregulus*	P
Family 5: Laridae		43. *Fulica atra*	G	**Family 27: Zosteropidae**	
17. *Chlidonias hybrida*	G	44. *Gallinula chloropus*	G	74. *Zosterops erythropleura*	P
18. *Chlidonias leucoptera*	G	45. *Porzna paykullii*	G	**ORDER 10: PELECANIFORMES**	
19. *Larus ridibundus*	G	46. *Rallus aquaticus*	G	**Family 28: Phalacrocoracidae**	
20. *Himantopus himantopus*	G	**Family 16: Otididae**		75. *Phalacrocorax carbo*	N
Family 6: Scolopacidae		47. *Otis tarda*	G	**ORDER 11: PICIFORMES**	
21. *Gallinago gallinago*	G	**ORDER 9: PASSERIFORMES**		**Family 29: Picidae**	
22. Gallinago stenura	G	**Family 17: Corvidae**		76. *Picus canus*	S
23. Numenius arquata	G	48. *Corvus corone*	P	**ORDER 12: PODICIPEDIFORMS**	
ORDER 3: CICONIIFORMES		49. *Corvus frugilegus*	P	**Family 30: Podicipedidea**	
Family 7: Ardeidae		50. *Corvus macrorhyncho*	P	77.*Podiceps cristatus*	N
24. *Ardea cinerea*	G	51. *Pica pica*	P	78.*Tachybaptus ruficollis*	N
25. *Ardea purpurea*	G	**Family 18: Emberizidae**		**ORDER 13: STRIGIFORMES**	
26. *Botaurus stellaris*	G	52. *Emberiza schoeniclus*	P	**Family 31: Strigidae**	
27. *Egretta eulophotes*	G	**Family 19: Fringllidae**	P	79. *Asio otus*	R
28. *Lxobrychus eurhythmus*		53. *Fringilla montifringilla*			
Family 8: Ciconiidae	G	54. *Loxia curvirostra*	P		
29. *Ciconia boyciana*	G	**Family 20: Hirundinidae**	P		
ORDER 4: COLUMBIFORMES		55. *Hirundo daurica*	p		
Family 9: Columbidae	T	56. *Hirundo rustica*			
30. *Columba livia*		57. *Riparia riparia*			

EG, ecological groups; N, natatores; G, grallatores; T, Terrestores; P, Passers; S, scansores.

Use of different habitat types

Chi-square test results showed a significant difference ($p < 0.01$) among the use of avian ecological groups and habitat types as shown in Table IV. More than 75% of the Passere population preferred reed marsh and forest belts, while less among them selected water bodies. More than 80% of the Grallatores population preferred water bodies and reed marsh, while less population preferred the farmland. More than 98% of the Natatores preferred water bodies and reed marsh. More than 90% of the Raptatores population preferred reed marsh and more than 94% of the Terre stores preferred reed marsh and farmland. Only the Scan sores population preferred forest belts. During autumn migration, the six avian ecological groups chose all habitat types, except meadow steppes. However, reed marsh and water bodies were the most preferred habitat types by the three dominant avian ecological groups.

Table III. Use of different water levels (WL) habitats by avian ecologicalgroups.

Water level habitat	Passeres	Grallatores	Natatores	Raptatores	Terrestores	Scansores
WL0	47.808	20.136	3.240	4.876	32.143	100.000
WL1	3.710	2.044	0.032	8.929	10.714	0.000
WL2	9.602	3.028	2.236	2.953	7.143	0.000
WL3	5.484	3.861	0.940	22.047	0.000	0.000
WL4	33.395	70.931	93.552	61.195	50.000	0.000
x2	76.700	173.500	254.000	116.000	47.760	-
P	0.000	0.000	0.000	0.000	0.000	-

WLO, no water; WL1, 0-5cm water level; WL2, 5-15cm water level; WL3, 15-30cm water level; WL4, more than 30cm water level.

Table IV. The use of different habitat types by avian ecological groups.

Habitat type	Passeres	Grallatores	Natatores	Raptatores	Terrestores	Scansores
Meadow steppe	2.610	0.858	0.000	1.168	5.357	0.000
Water bodies	14.679	57.885	72.521	0.069	0.000	0.000
Reed marsh	41.978	24.174	25.988	93.952	78.571	0.000
Farmland	7.319	17.083	1.491	0.275	16.071	0.000
Forest belts	33.415	0.000	0.000	4.536	0.000	100.000
*x*2	56.800	69.200	80.180	165.860	95.660	-
P	0.000	0.000	0.000	0.000	0.000	-

Table V. The preferred habitats of the avian ecological groups.

Avian ecological group	Water level	Habitat type
Passeres	WL0> WL4	reed marsh> forest belts > water bodies
Grallatores	WL4 > WL0	water bodies >reed marsh> farmland
Natatores	WL4	water bodies >reed marsh
Raptatores	WL4 > WL3	reed marsh
Terrestores	WL4> WL0	reed marsh> farmland
Scansores	WL0	forest belts

For details of water levels see Table III.

Habitat preference

During autumn migration, six avian ecological groups had different habitat preferences regarding water levels and habitat types as shown in Table V. The habitat preference of passeres was forest belts with no water surface (WL0), reed marsh and water bodies with water deeper than 30 cm (WL4). The grallatores preferred water bodies and reed marsh with water depth higher than 30 cm (WL4) and farmland with no water surface (WL0). The natatores preferred water bodies and reed marsh with higher than 30 cm water depth (WL4). The raptatores preferred reed marsh with water depth higher than 15 cm (WL4 > WL3), while the terrestores preferred reed marsh with water depth higher than 30 cm (WL4) and farmland with no water surface (WL0). Only the scan sores preferred forest belts with no water surface (WL0).

From the collected data it can be concluded that water bodies with higher than 30 cm water depth (WL4), reed marsh with more than 15 cm water depth (WL4 and WL3), farmland with no water surface, and forest belts with no water surface were the dominant habitats chosen by these six avian ecological groups, during autumn migration. The reed marsh with more than 30 cm water depth (WL4) was the mutually preferred habitat by the three dominant avian ecological groups. This showed the existence of an overlap distribution area for the three dominant avian ecological groups, represented by the reed marsh area with more than 30 cm water depth (WL4). Similarly, water bodies with more than 30 cm water depth (WL4) were another overlap distribution area for the passere and grallatore populations.

Dominant avian ecological groups had close relationships with the dominant vegetation environment. In Zhalong, wetland environment with reed marsh and water bodies is the absolute dominant vegetation environment. As a result, the grallatores and natatores were the two main avian ecological groups depending on the wetland environment. The passeres were the main avian ecological group in the Northeast district, China (Zhao, 1988).

This research showed a consistent result. The dominant vegetation environment and geographical region are the two important influencing factors of the distribution of dominant avian ecological groups during autumn migration in Zhalong.

DISCUSSION

The results indicate that Passeriformes, Anseriformes and Charadriiformes were the main species in bird communities, followed by Gruiformes, Ciconiiformes and Falconiformes orders. The Zhalong National Nature Reserve shelters all the six ecological groups' occurring in China. The passeres had the largest number of birds among the six avian ecological groups, followed by the grallatores and natatores. This fact is closely related with the unique wetland environmental characteristics of the region. The previous studies have shown that the bird community structure was abundant with the Passeriformes being dominant for non-waterfowl and the Charadriiformes dominant for waterfowl in Zhalong (Guan *et al*., 2009). The area has a complete wetland ecosystem that provides a good habitat for the grallatores and natatores. At the same time, the passeres was the main bird population observed in the northeast, by this survey. As species components and dominant avian ecological groups, the richness of species recorded by this study was far more abundant than the previous records (Guan, 2009). There might be two reasons causing the difference. One of the potential reasons could be the sampling areas number. The sampling areas for this research were 101, which were by far more than the previous research with three line-transect sampling areas. This is probably the main reason that generated the significant difference. Another reason is the studied area which in this survey is the entire reserve area, while the previous research observed only one part of the reserve.

Effect of different water levels on avian distribution

During the autumn migration period, different ecological groups have shown evident preferences for different water levels (Zou *et al*., 2016). Large waders such as the Gruiformes and Ciconiiformes were inhabited in deepwater environments while some small wading birds preferred no water surface environment, such as the Charadriiformes. The passeres and terrestores selected both waterless and aquatic environments due to their specific traits. Because of the high frequency of human activities such as fishing, the natatores chose to live in the deep-water area during autumn. Scan sores preferred to choose the waterless environment. Numerous studies have shown that 68 waterfowl species having different measures in length and size, exhibit different needs for food types, habitats and water depths. The difference in water levels is particularly significant for wetland habitats, especially food resources and habitat environments. Therefore, each waterfowl has its optimum water level and available water level requirements.

Effect of different habitat types on avian distribution

This study results suggest that during the autumn migration period, different ecological groups showed significant differences in choosing different habitats except for the Scan sores. Water bodies were chosen mainly by the Grallatores and natatores, followed by the passeres, the reed marsh mainly used by the raptatores and terrestores, followed by the natatores and passeres. The meadow steppes were mainly chosen by the passeres and raptatores while farmland was mainly used by the grallatores and terrestores, followed by the passeres and natatores. The forest belts mainly had sheltered the Scan sores, followed by the passeres and raptatores. Considering the chosen locations of birds in different habitats, the choice of ecological groups showed overlapping and differentiation. In addition, the water bodies, reed marsh and farmlands were the main habitats of ecological communities, providing breeding and resting places for birds. There is a certain competitive relationship between rare animals and ordinary wild animals in the utilization of wetland resources during the migration period. The research on the influence of environmental factors such as water level on the habitat of autumn migration can help to take more effective protection measures for rare animals.

Effect of habitat preferences on avian distribution

The natural ecosystem of Zhalong National Nature Reserve provides a high-quality living place for all kind of birds. The reed marsh habitats with different water levels are ideal habitats for large waders such as the cranes. There are open lakes providing a good source of food and resting places for all kinds of avians like Anseriformes, Podicipediformes and Charadriiformes. The passeres have a wide range of activities and they are distributed in the reed marsh with deep water levels and forest belts. Different water levels affect the growth and distribution of wetland organisms, type, structure and composition of wetlands. Thus, different water levels and habitat types are

particularly important for bird habitat selection.

CONCLUSION

In Zhalong Nature Reserve, a total of 79 bird species belonging to 32 families and 13 orders were observed during autumn migration, including six avian ecological groups namely grallatores, passeres, natatores, raptatores, scan sores and terrestores. The passeres, grallatores and natatores were the three dominant avian ecological groups during autumn migration; and reed marsh with more than 30 cm water depth (WL4) and water bodies with more than 30 cm water depth (WL4) were their most preferred habitats. Different avian ecological groups had a different preference for water levels ($P < 0.01$) and habitat types ($P < 0.01$). Further analysis showed that reed marsh and water bodies with deep water depth were the main overlap habitat of different avian ecological groups especially the dominant groups, dominant wetland vegetation environment and unique geographical region were the key influencing factors of avian ecological group's spatial distribution. Based on this research, reed marsh and water bodies need more attention during autumn migration to preserve the avian diversity of the reserve.

In general, birds of different ecological groups have different requirements for habitat, and the same species also has different characteristics for habitat selection in different spaces, seasons and life periods. Appropriate water level changes will produce relatively diverse vegetation environment and habitat types, which will help to provide various types of habitats for different bird species. Therefore, moderate artificial regulation of water level can contribute to the construction of bird habitats and the scientific management of birds in Zhalong area. According to the distribution characteristics of birds in the protected area, the target birds are determined to restore the species, and the appropriate living space of birds is created based on the observed results.

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IRB approval and ethics statement

IRB approval have been given by Advisory Committee of Northeast Forestry University No.26, Hexing Road, Xiangfang District, Harbin City, Heilongjiang, China. All the procedures were carried out according to the institutional guidelines.

Statement of conflict of interest

The authors have declared no conflict of interest.

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