

**Table S1** Functional traits used for functional characterization of the bird

Trait types	Defined categories	References material
Beak.Length_Clumen	A. Continuous variables	[62]
Beak.Length_Nares	B. Continuous variables	
Beak.Width	C. Continuous variables	
Beak.Depth	D. Continuous variables	
Kipps.Distance	E. Continuous variables	
Wing length	F. Continuous variables	[63]
Tail length	G. Continuous variables	
Tarsus length	H. Continuous variables	[64]
Diet	I. Omnivorous	[65]
	J. Herbivorous	
	K. Seed-feeding	
	L. Insectivorous	
	M. Carnivorous	
	N. Frugivorous	

### Interpretation of trait indexes

The four indicators of the beak are: Length from the tip of the beak to the base of the skull (Beak.Length\_Clumen), Length from the anterior edge of the nostrils to the tip of the beak (Beak.Length\_Nares), Width of the beak at the anterior edge of the nostrils (Beak.Width), Width of the beak at the anterior edge of the nostrils (Beak.Depth). Kipp's distance is the length from the tip of the first secondary feather to the tip of the longest primary. Wing length, Tail length and Tarsus length take the mean of male and female individuals. We classified species into dietary guilds based on of diets for the world's birds, this trophic group was defined when its primary feeding group was >50%, when all trophic groups were ≤50%, both were included in the analysis if two were present, and omnivorous if three or more dietary guilds were present.

### References

62. Tobias, J.A.; Sheard, C.; Pigot, A.L.; et al. AVONET: morphological, ecological and geographical data for all birds. *Ecology Letters* 2022, 25, 581-597. <https://doi.org/10.1111/ele.13898>
63. Wang, X.T. Vertebrate Fauna of Gansu Province. Gansu Science and Technology Press, Lanzhou, 1991.
64. Wang, Y.P.; Song, Y.F.; Zhong, Y.Q.; Chen, C.W.; Zhao, Y.H.; Zeng, D.; Wu, Y.R.; Ding, P. A dataset on the life-history and ecological traits of Chinese birds. *Biodiversity Science* 2021, 29, 1149-1153. DOI: 10.17520/biods.2021201

65. Wilman, H.; Belmaker, J.; Simpson, J. EltonTraits 1.0: Species-level foraging attributes of the world's birds and mammals: Ecological Archives E095-178. *Ecology* 2014, 95, 2027-2027. <https://doi.org/10.1890/13-1917.1>

**Table S2** Bird composition of different land use types

Order	Family	Species	Bird distribution in different land use types					
			PFL	AFL	TGL	ACK	APO	AMF
Galliformes	Phasianidae	<i>Alectoris magna*</i>	+	+	+			
		<i>Perdix dauurica</i>	+		+			
		<i>Phasianus colchius</i>	+	+	+	+	+	+
Columbiformes	Columbidae	<i>Columba rupestris</i>	+	+	+	+	+	
		<i>Streptopelia chinensis</i>	+	+				
Cuculiformes	Cuculidae	<i>Cuculus canorus</i>	+	+			+	
Caprimulgiformes	Apodidae	<i>Apus apus</i>						
Accipitriformes	Accipitridae	<i>Buteo hemilasius</i>						
		<i>Buteo japonicus</i>						
Strigiformes	Strigidae	<i>Bubo bubo</i>			+	+		+
		<i>Athene noctua</i>		+				
Bucerotiformes	Upupidae	<i>Upupa epops</i>	+	+		+		+
Piciformes	Picidae	<i>Dendrocopos major</i>	+	+				+
		<i>Picus canus</i>	+	+				+
Falconiformes	Falconidae	<i>Falco tinnunculus</i>						
Passeriformes	Oriolidae	<i>Oriolus chinensis</i>	+					
	Laniidae	<i>Lanius tephronotus</i>	+	+		+	+	+
	Corvidae	<i>Pica pica</i>	+	+	+			
		<i>Pyrrhocorax pyrrhocorax</i>	+	+	+	+	+	
		<i>Cyanopica cyanus</i>						
		<i>Parus cinereus</i>	+	+		+	+	+
		<i>Pardaliparus venustulus*</i>						+
	Remizidae	<i>Remiz coronatus</i>						+

	Hirundinidae	<i>Hirundo rustica</i>						
	Pycnonotidae	<i>Pycnonotus sinensis</i>						+
	Phylloscopidae	<i>Phylloscopus armandii</i>				+		+
		<i>Phylloscopus trochiloides</i>						+
	Aegithalidae	<i>Aegithalos glaucogularis</i>						+
	Sylviidae	<i>Rhopophilus pekinensis</i>				+		
	Leiothrichidae	<i>Garrulax davidi*</i>	+	+		+	+	+
	Sittidae	<i>Tichodroma muraria</i>						
	Sturnidae	<i>Spodiopsar cineraceus</i>	+					
	Turdidae	<i>Turdus rubrocanus</i>	+	+				+
		<i>Zoothera aurea</i>						
	Muscicapidae	<i>Phoenicurus ochruros</i>	+	+	+	+	+	
		<i>Phoenicurus aureoreus</i>	+	+		+	+	+
		<i>Oenanthe isabellina</i>				+		
		<i>Oenanthe pleschanka</i>	+	+	+	+	+	
	Passeridae	<i>Passer montanus</i>	+	+		+	+	
	Motacillidae	<i>Motacilla alba</i>	+	+				
	Fringillidae	<i>Pyrrhula erythaca</i>						+
		<i>Carpodacus pulcherrimus</i>					+	
		<i>Carpodacus stoliczake</i>		+				
		<i>Chloris sinica</i>	+				+	+
	Emberizidae	<i>Emberiza godlewskii</i>	+	+	+	+		
		<i>Emberiza cioides</i>	+	+	+	+	+	

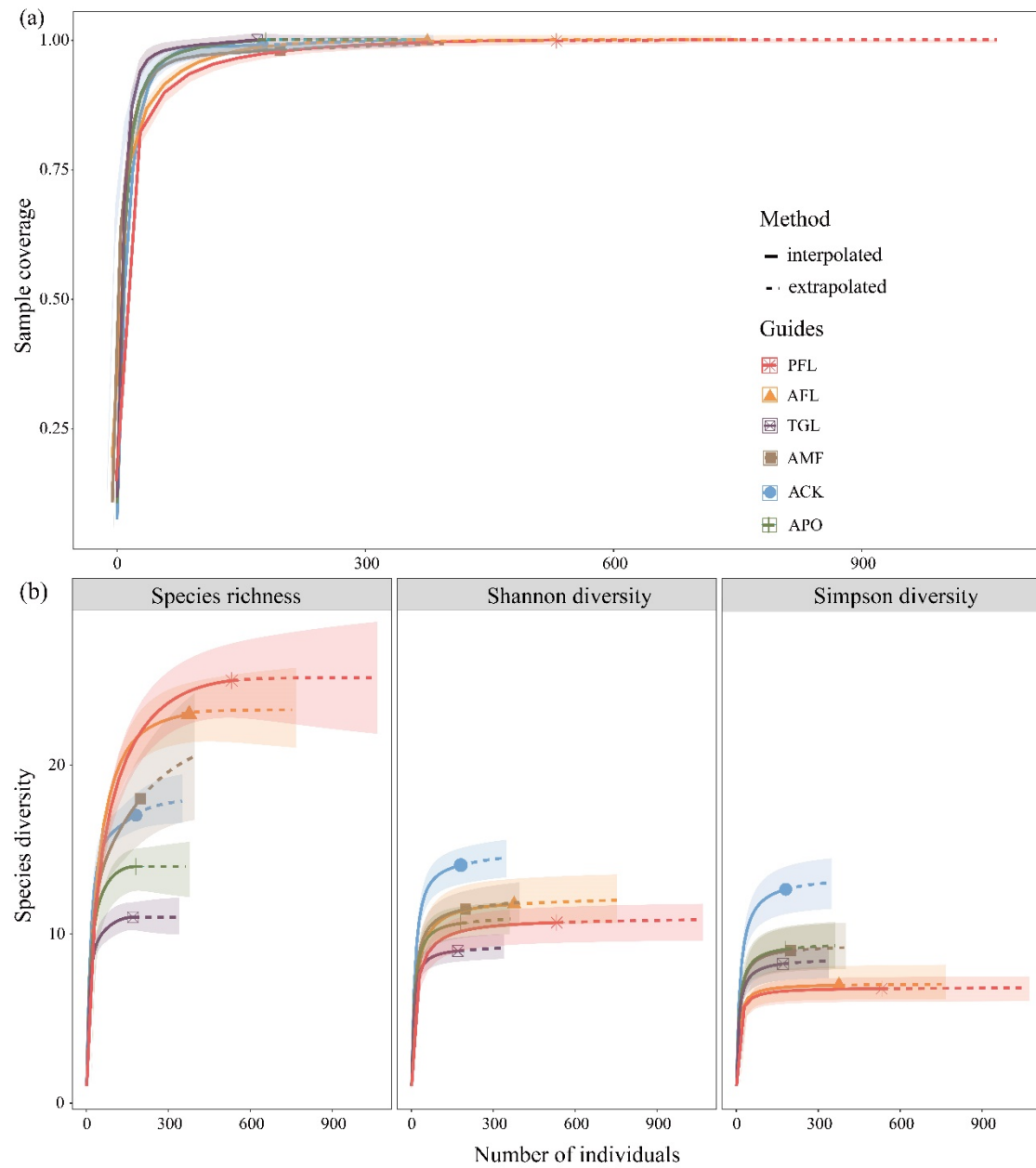
Note: \*represents Chinese endemic species.

**Table S3** Comparisons of different components of multidimensional  $\beta$  diversity in bird

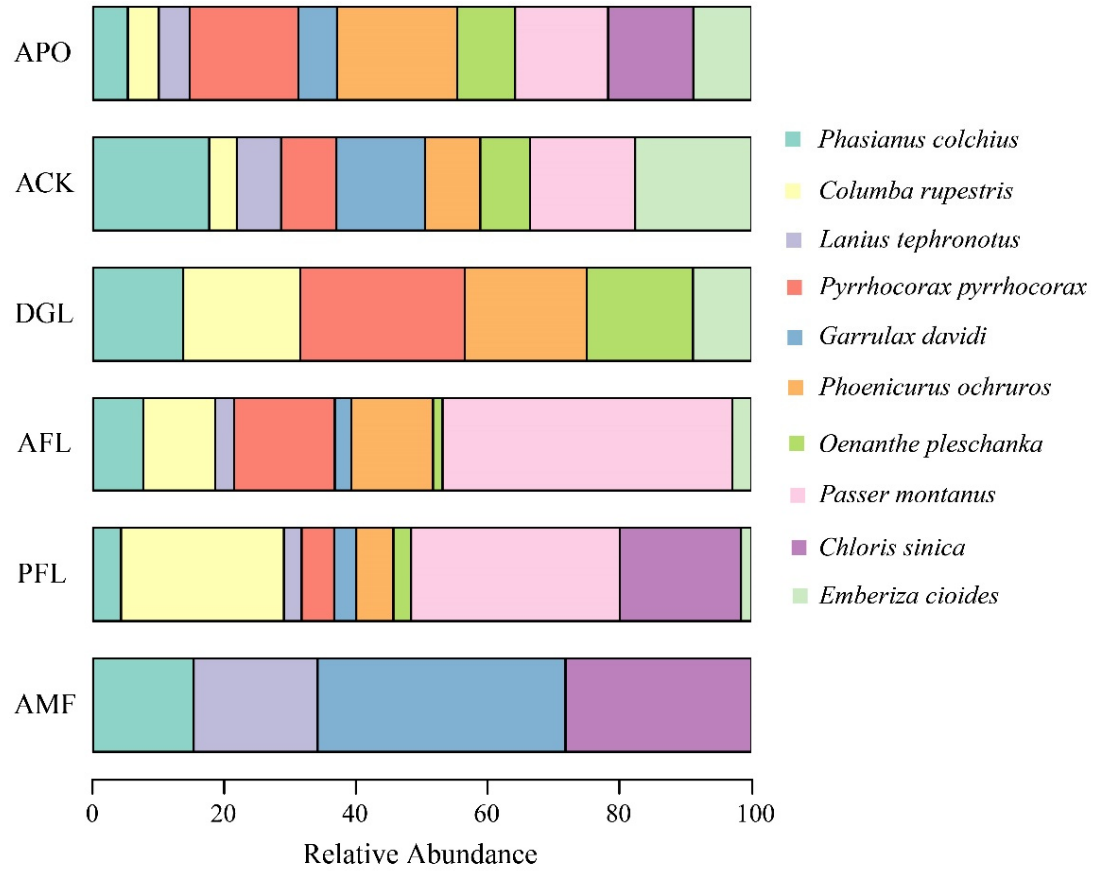
Comparison	<i>P-Value</i>	Patterns
Taxonomic total dissimilarity vs. Functional total dissimilarity	$p < 0.001$	Taxonomic total dissimilarity < Functional total dissimilarity
Taxonomic total dissimilarity vs. Phylogenetic total dissimilarity	$p < 0.001$	Taxonomic total dissimilarity > Phylogenetic total dissimilarity
Functional total dissimilarity vs. Phylogenetic total dissimilarity	$p < 0.001$	Functional total dissimilarity > Phylogenetic total dissimilarity
Taxonomic turnover vs. Functional turnover	$p < 0.001$	Taxonomic turnover < Functional turnover
Taxonomic turnover vs. Phylogenetic turnover	$p < 0.001$	Taxonomic turnover > Phylogenetic turnover
Functional turnover vs. Phylogenetic turnover	$p < 0.001$	Functional turnover > Phylogenetic turnover
Taxonomic nestedness vs. Functional nestedness	$p < 0.001$	Taxonomic nestedness < Functional nestedness
Taxonomic nestedness vs. Phylogenetic nestedness	0.006	Taxonomic nestedness < Phylogenetic nestedness
Functional nestedness vs. Phylogenetic nestedness	$p < 0.001$	Functional nestedness > Phylogenetic nestedness
Taxonomic turnover vs. Taxonomic nestedness	$p < 0.001$	Taxonomic turnover > Taxonomic nestedness
Functional turnover vs. Functional nestedness	$p < 0.001$	Functional turnover > Functional nestedness
Phylogenetic turnover vs. Phylogenetic nestedness	$p < 0.001$	Phylogenetic turnover > Phylogenetic nestedness

**Table S4** Composition of common plant species in different land use types

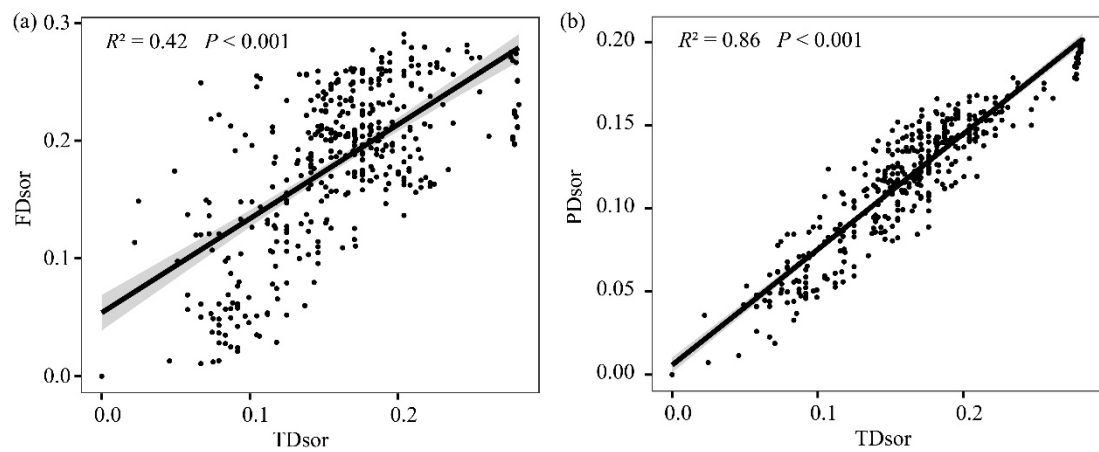
Land use types	Plant composition	
	herbs	Shrubs and trees
PFL	1. <i>Zea mays</i> , <i>Glycine max</i> , <i>Pisum sativum</i> , <i>Solanum tuberosum</i> , <i>Linum usitatissimum</i> , <i>Fagopyrum esculentum</i> , <i>Medicago sativa</i> , <i>Sorghum bicolor</i> , <i>Setaria italica</i> , <i>Panicum miliaceum</i> , <i>Glycyrrhiza uralensis</i> , <i>Scutellaria baicalensis</i> , 2. <i>Sonchus brachyotus</i> , <i>Chenopodium glaucum</i> , <i>Setaria viridis</i> , <i>Parthenocissus tricuspidate</i> , <i>Erodium stephanianum</i> , <i>Corispermum mongolicum</i> , <i>Convolvulus arvensis</i> , <i>Lappula myosotis</i> , <i>Lxeridium chinense</i> , 3. <i>Saussurea japonica</i> , <i>Carduus nutans</i> , <i>Heteropappus altaicus</i> , <i>Artemisia scoparia</i> , <i>Leymus chinensis</i> , <i>Adenophora polyantha</i> , <i>Poa sphondylodes</i> , <i>Astragalus Melilotoides</i> , <i>Delphinium grandiflorum</i> , <i>Leonurus artemisia</i> , <i>Artemisia gmelinii</i> , <i>Bupleurum chinense</i>	<i>Populus L.</i> , <i>Ulmus pumila</i> , <i>Salix matsudana</i> , <i>Armeniaca sibirica</i> , <i>Malus pumila</i> , <i>Ailanthus altissima</i>
AFL	<i>Artemisia gmelinii</i> , <i>Convolvulus arvensis</i> , <i>Heteropappus altaicus</i> , <i>Peganum Harmala</i> , <i>Saussurea japonica</i> , <i>Adenophora polyantha</i> , <i>Viola prionantha</i> , <i>Picris hieracioides</i> , <i>Potentilla multicaulis</i> , <i>Euphorbia esula</i> , <i>Astragalus melilotoides</i> , <i>Potentilla bifurca</i> , <i>Lxeridium chinense</i> , <i>Lespedeza potaninii</i> , <i>Silene foliosa</i> , <i>Leymus chinensis</i> , <i>Setaria viridis</i> , <i>Poa sphondylodes</i> , <i>Leymus secalinus</i> , <i>Artemisia scoparia</i> , <i>Achnatherum splendens</i> , <i>Leonurus artemisia</i> , <i>Acroptilon repens</i>	<i>Lycium chinense</i> , <i>Populus L.</i> , <i>Ulmus pumila</i> , <i>Salix matsudana</i> , <i>Armeniaca sibirica</i> , <i>Ailanthus altissima</i> , <i>Tamarix chinensis</i>
TGL	<i>Artemisia frigida</i> , <i>Leymus secalinus</i> , <i>Achnatherum splendens</i> , <i>Stellera chamaejasme</i> , <i>Ephedra sinica</i> , <i>Thermopsis lanceolata</i> , <i>Heteropappus altaicus</i>	<i>Caragana roborovskii</i>
AMF	<i>Lespedeza daurica</i> , <i>Diarrhron linifolium</i> , <i>Poa sphondylodes</i>	<i>Hippophae rhamnoides</i> , <i>Pinus tabuliformis</i> , <i>Armeniaca sibirica</i> , <i>Populus hopeiensis</i> , <i>Tamarix chinensis</i>
ACK	<i>Leymus secalinus</i> , <i>Gueldenstaedtia stenophylla</i> , <i>Thalictrum foeniculaceum</i> , <i>Eruca sativa</i> , <i>Glycyrrhiza uralensis</i> , <i>Ephedra sinica</i>	<i>Caragana korshinskii</i>
APO	<i>Glycyrrhiza uralensis</i> , <i>Ephedra sinica</i> , <i>Leymus secalinus</i> , <i>Thermopsis lanceolata</i> , <i>Artemisia frigida</i>	<i>Platycladus orientalis</i>



**Figure S1.** Bird diversity estimates across land use types. (a) Individual-based species sampling coverage curves; (b) comparison of diversity index, with 95% confidence intervals.

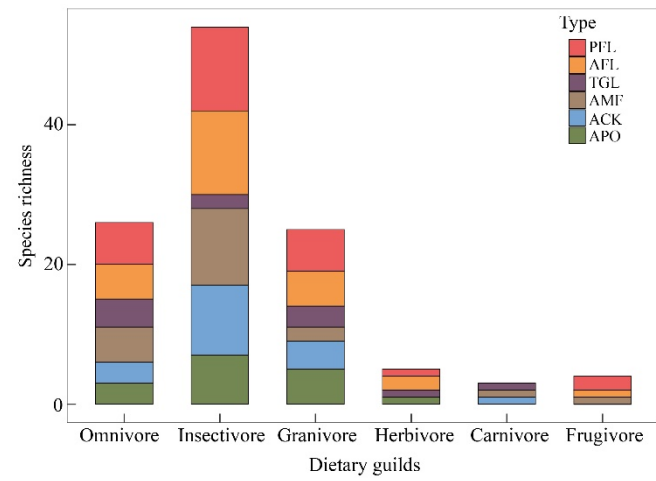


**Figure S2.** Percentage proportions of raw abundances of the 10 most abundant birds.



**Figure S3** Relationships between total TD dissimilarity with total FD and PD dissimilarity of birds.





**Figure S4** Distribution of avian dietary guilds in different land use types.