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Influenza A Virus Infections in Land Birds, People's Republic of China

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Water birds are considered the reservoir for avian influenza viruses. We examined this assumption by sampling and real-time reverse transcription–PCR testing of 939 Asian land birds of 153 species. Influenza A infection was found, particularly among migratory species. Surveillance programs for monitoring spread of these viruses need to be redesigned.

Avian influenza virus ecology has long regarded waterbirds as a primary reservoir. Although the benchmark study detailed prevalences across all taxa (*1*), subsequent studies have focused exclusively on waterbirds (*2*) with few exceptions (*3*,*4*). We reexamined these assumptions on the basis of a broad sampling of bird diversity in Southeast Asia, where bird-borne influenza viruses are of particular concern (*5*). We sampled and tested diverse land birds for influenza A virus infection and showed that land birds also harbor infections with these viruses. Birds in these taxa are not irrelevant in virus transmission and should form an integral part of avian influenza surveillance and monitoring programs.

The Study

During 2004–2007, as part of a broader biodiversity survey and inventory program, we sampled birds from mostly forested sites in Guangxi and Guizhou Provinces in the southern part

of the People's Republic of China (Figure). Sampling was conducted by mist netting and selective harvesting with shotguns; all birds in the study were apparently healthy and behaving normally at the time of collection. Because initial sampling was focused on endoparasite communities, samples from 2004–2005 consisted of complete gastrointestinal tracts frozen in liquid nitrogen. In 2006–2007, sampling was conducted specifically for viruses. Cloacal swabs were collected in 2006 and buccal–cloacal swabs were collected in 2007. All swabs were preserved in 95% ethanol.

A total of 184 samples were collected from Jing Xi municipality in Guangxi (21.122°N, 105.964°E) in 2004, 130 from Shiwandashan Nature Reserve in Guangxi (21.840°N, 107.880°E) in 2005, 103 from Dashahe Nature Reserve in Guizhou (29.167°N, 107.575°E) in 2006, 194 from Kuan Kuoshui Nature Reserve in Guizhou (28.226°N, 107.160°E) in 2006, and 328 from Shuipu village, Guizhou Province (25.485°N, 107.882°E) in 2007 (Figure). Samples were tested for influenza A virus by real-time reverse transcription–PCR (*6*) in 2 diagnostic laboratories (Southeast Poultry Research Laboratory, US Department of Agriculture, Athens, GA, USA, and National Wildlife Health Center, US Geological Survey, Madison, WI, USA).

Of 939 samples tested, 24 were positive for influenza A viruses (prevalence 2.3%) (Table; complete summary in Appendix Table). If migratory behavior (species classified as migratory or nonmigratory on the basis of descriptions by MacKinnon and Phillipps [*7*]), was considered, 11 (4.8%) of 231 samples from species showing marked seasonal migrations were influenza positive. However, only 13 (1.8%) of 708 samples from nonmigratory species were positive. The cumulative binomial probability that such a high number (*11*) of positive samples would result among the 231 migratory-species samples, were the true prevalence to be 1.8%, is low ($p = 0.0013$). Thus, migratory species appear to have higher influenza infection rates. In terms of general habitat use (*7*), open-country species were slightly more prone to be influenza positive (8 [2.9%] of 274 samples) than forest species (16 [2.4%] of 665 samples), but the difference was not significant (cumulative binomial probability, $p>0.05$). Interactions between migratory behavior and habitat use were not significant (contingency test, $p>0.05$). Although all infections detected were among songbirds (Passeriformes), the sampling also concentrated on songbirds (94.3%). Thus, we could not test adequately the hypothesis that influenza prevalence was equivalent between songbirds and other birds.

An obvious question is whether the influenza A viruses we detected belong to the highly pathogenic subtype H5N1 strain currently circulating across much of Asia. All samples were negative for the H5 subtype by real-time reverse transcription–PCR (*6*), although this result does not exclude the possibility that H5 viruses were among the positive samples. The preservation status of samples we tested prevented virus isolation or full, strain-level characterization of influenza viruses.

Conclusions

The subtype H5N1 strain of influenza virus has spread rapidly and has been detected across much of central and southern Eurasia. Although movements of wild birds have been implicated in this spread (*8*), other studies question (*9*,*10*) or contradict (*11*) this idea. An important part of the argument centers on the question of the occurrence of the virus in wild birds without obvious illness, which can be difficult to interpret given the low prevalence of influenza. For instance, a recent study based on sampling >13,000 migratory birds in China detected the subtype H5N1 strain of influenza virus only 8 times (*12*), and similar results have been obtained elsewhere (*2*). Our study, although not successful in characterizing influenza viruses to specific strains, nonetheless shows that influenza A virus infection occurs in more bird species than previously assumed and that influenza A infections can be found in birds that behave normally and show no sign of illness.

Although a review of avian influenza virus ecology (*1*) discussed the occurrence of influenza viruses across all groups of birds (and other vertebrates), subsequent studies have assumed that waterbirds are the primary reservoir (*8*,*13*,*14*). In this study, a broad sample of land birds yielded frequent influenza-positive results. Although waterbirds could have higher prevalences, we have demonstrated broad occurrence of influenza viruses in diverse taxa of Passeriformes (songbirds) in Southeast Asia. This result suggests that land birds may also be a major reservoir of influenza viruses.

We have taken a step toward a more complete understanding of influenza virus ecology among wild birds. Our partial survey of influenza virus distributions across the rich avifaunas of the southern region of China demonstrated frequent infections. This result contrasts with the

current dogma in the influenza surveillance community. We suggest that to be effective future surveillance efforts will need to include the full diversity of wild birds.

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References

1. Webster RG, Bean WJ, Gorman OT, Chambers TM, Kawaoka Y. Evolution and ecology of influenza A viruses. Microbiol Rev. 1992;56:152–79. PubMed

2. Winker K, McCracken KG, Gibson DD, Pruett CL, Meier R, Huettmann F, et al. Movements of birds and avian influenza from Asia into Alaska. Emerg Infect Dis. 2007;13:547–52. PubMed

3. Kou Z, Lei FM, Yu J, Fan ZJ, Yin ZH, Jia CX, et al. New genotype of avian influenza H5N1 viruses isolated from tree sparrows in China. J Virol. 2005;79:15460–6. PubMed DOI: 10.1128/JVI.79.24.15460-15466.2005

4. Boon AC, Sandbulte MR, Seiler P, Webby RJ, Songserm T, Guan Y, et al. Role of terrestrial wild birds in ecology of influenza A virus (H5N1). Emerg Infect Dis. 2007;13:1720–4. PubMed

5. Boyce W. Earth monitoring: vigilance is not enough. Nature. 2007;450:791–2. PubMed DOI: 10.1038/450791a

6. Spackman E, Senne DA, Myers TJ, Bulaga LL, Garber LP, Perdue ML, et al. Development of a real-time reverse transcriptase PCR assay for type A influenza virus and the avian H5 and H7 hemagglutinin subtypes. J Clin Microbiol. 2002;40:3256–60. PubMed DOI: 10.1128/JCM.40.9.3256-3260.2002

7. MacKinnon J, Phillipps K. A field guide to the birds of China. Oxford (UK): Oxford University Press; 2000.

8. Taubenberger JK, Morens DM. Influenza revisited. Emerg Infect Dis. 2006;12:1–2. PubMed

9. Melville DS, Shortridge KF. Spread of H5N1 avian influenza virus: an ecological conundrum. Lett Appl Microbiol. 2006;42:435–7. PubMed DOI: 10.1111/j.1472-765X.2006.01892.x

10. Kilpatrick AM, Chmura AA, Gibbons DW, Fleischer RC, Marra PP, Daszak P. Predicting the global spread of H5N1 avian influenza. Proc Natl Acad Sci U S A. 2006;103:19368–73. PubMed DOI: 10.1073/pnas.0609227103

11. BirdLife International. BirdLife statement on avian influenza. Cambridge (UK): BirdLife International; 2006 [cited 2008 Jul 23]. Available from http://www.birdlife.org/action/science/species/avian_flu

12. Chen HX, Shen HG, Li XL, Zhou JY, Hou YQ, Guo JQ, et al. Seroprevalance and identification of influenza A virus infection from migratory wild waterfowl in China (2004–2005). J Vet Med B Infect Dis Vet Public Health. 2006;53:166–70. PubMed DOI: 10.1111/j.1439-0450.2006.00940.x

13. Olsen B, Munster VJ, Wallensten A, Waldenström J, Osterhause AD, Fouchier RA. Global patterns of Influenza A virus in wild birds. Science. 2006;312:384–8. PubMed DOI: 10.1126/science.1122438

14. Webster RG, Peiris M, Chen H, Guan Y. H5N1 outbreaks and enzootic influenza. Emerg Infect Dis. 2006;12:3–8. PubMed

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Table. Prevalence of influenza A virus in avian orders and families at 5 sites, People's Republic of China

Order	Family	Location, no. positive/no. tested				
		Dashahe	Jing Xi	Kuan Kuoshui	Shiwandashan	Shuipu
Apodiformes	Apodidae	0/4				
Caprimulgiformes	Caprimulgidae				0/2	0/1
Charadriiformes	Scolopacidae		0/1			
Ciconiiformes	Ardeidae		0/1		0/1	
Columbiformes	Columbidae	0/1	0/1	0/1	0/1	
Coraciiformes	Alcedinidae		0/1		0/1	0/4
Cuculiformes	Cuculidae			0/1	0/1	
Gruiformes	Rallidae					0/1
Passeriformes	Aegithalidae	0/3				0/11
	Aegithinidae		0/1			0/2
	Campephagidae	0/1	0/4	0/1	0/8	0/4
	Cinclidae	0/5				
	Corvidae	0/2	0/1	0/3		
	Dicaeidae				0/6	
	Dicruridae		0/8		0/1	
	Emberizidae	0/10		3/18		0/20
	Estrilididae					0/13
	Fringillidae			0/1		0/6
	Hirundinidae					0/3
	Laniidae					0/1
	Monarchidae		0/6		0/8	
	Motacillidae	0/3	1/4	0/1		0/12
	Muscicapidae	2/18	2/42	1/26	0/31	1/55
	Nectariniidae			0/1	0/7	0/2
	Panuridae	0/2	0/1	0/11		0/6
	Paridae	0/2	0/1	1/20		0/10
	Passeridae	1/1		1/1		0/11
	Pycnonotidae	0/9	0/8	0/4	0/18	0/47
	Sturnidae	0/1				
	Sylviidae	1/20	1/34	2/21	0/13	1/20
	Timaliidae	0/20	1/64	3/76	0/25	1/76
	Turdidae					0/2
	Zosteropidae			1/1	0/1	0/11
Piciformes	Capitonidae				0/1	
	Picidae	0/1	0/5	0/6	0/4	0/11
Podicipediformes	Podicipedidae			0/1		
Trogoniformes	Trogonidae		0/1			

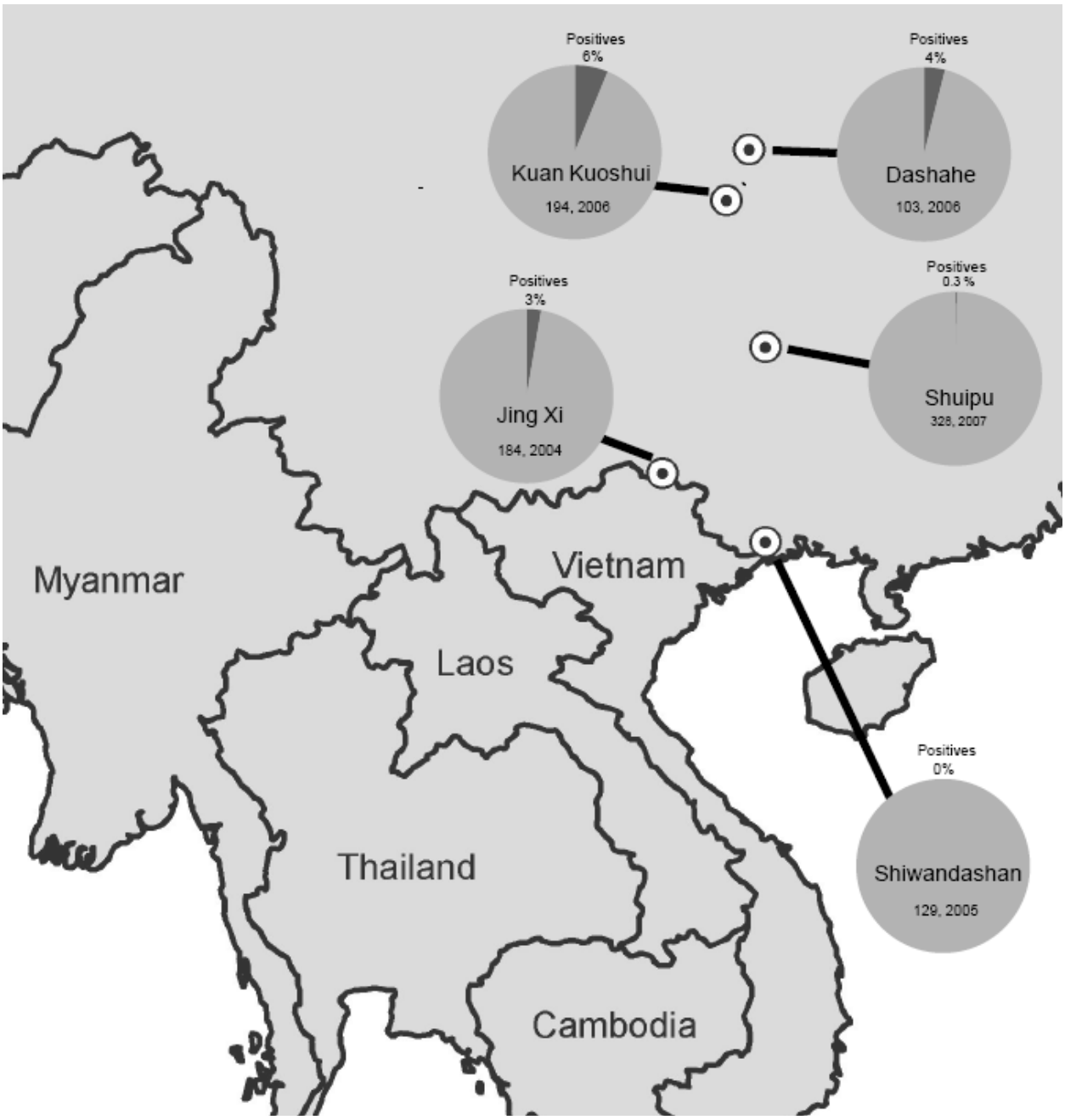

Figure. Southeastern Asia, showing 5 sites in the People's Republic of China where land birds were collected and tested for influenza A virus. Prevalence values were 4% (n = 103) in Dashahe in 2006; 6% (n =194) in Kuan Kuoshui in 2006; 0.3% (n = 328) in Shuipu in 2007; 3% (n =184) in Jing Ki, in 2004; and 0% (n = 129) in Shiwandashan in 2005.

Appendix Table. Summary of individual birds tested, People's Republic of China*

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
Apodiformes	Apodidae	*Apus pacificus*	Dashahe	97415, 97621,98120, 98940	0	4	M	O
Caprimulgiformes	Caprimulgidae	*Caprimulgus indicus*	Shiwandashan	96345, 96346	0	2	M	O
			Shuipu	99676	0	1	M	O
Charadriiformes	Scolopacidae	*Gallinago rusticola*	Jing Xi	96395	0	1	M	O
Ciconiiformes	Ardeidae	*Butorides striatus*	Jing Xi	93320	0	1	M	O
		Gorsachius melanolophus	Shiwandashan	96393	0	1	M	F
Columbiformes	Columbidae	*Chalcophaps indica*	Jing Xi	93308	0	1	R	F
			Shiwandashan	96422	0	1	R	F
		Streptopelia chinensis	Dashahe	97413	0	1	R	O
		S. orientalis	Kuan Kuoshui	97407	0	1	R	O
Coraciiformes	Alcedinidae	*Alcedo hercules*	Jing Xi	93313	0	1	R	F
		A. atthis	Shuipu	99683, 99684, 99685, 99956	0	4	R	O
		Ceyx erithacus	Shiwandashan	96412	0	1	R	F
Cuculiformes	Cuculidae	*Cuculus micropterus*	Kuan Kuoshui	97406	0	1	R	F
		Phaeniocophaeus tristis	Shiwandashan	96418	0	1	R	F
Gruiformes	Rallidae	*Amaurornis phoenicurus*	Shuipu	99677	0	1	R	O
Passeriformes	Aegithalidae	*Aegithalos concinnus*	Dashahe	97478, 97620, 98936	0	3	R	F
			Shuipu	99423, 99424, 99760, 99761, 99762, 99763, 99764, 99765, 99948, 99963, 1 not catalogued	0	11	R	F
	Aegithinidae	*Chloropsis hardwickii*	Jing Xi	93411	0	1	R	F
			Shuipu	99686, 99687	0	2	R	F
	Campephagidae	*Coracina macei*	Jing Xi	93314, 93315	0	2	R	F
		C. melaschistos	Jing Xi	96238	0	1	R	F
			Kuan Kuoshui	97461	0	1	R	F
		Hemipus picatus	Jing Xi	96587	0	1	R	F
			Shiwandashan	96512	0	1	R	F
		Pericrocotus divaricatus	Shiwandashan	96485, 96486, 96487	0	3	M	F
		P. ethologous	Dashahe	97433	0	1	R	F
		P. flammeus	Shiwandashan	96488, 96489, 96490, 96491	0	4	R	F
			Shuipu	99945, 99691	0	2	R	F
		P. solaris	Shuipu	99945, 99691	0	2	R	F
	Cinclidae	*Cinclus pallasii*	Dashahe	97487, 97488, 98937, 99345, 99359	0	5	R	F
	Corvidae	*Dendrocitta formosae*	Jing Xi	93319	0	1	R	F
		Garrulus glandarius	Kuan Kuoshui	97526	0	1	R	F
		Urocissa erythrorhyncha	Dashahe	1 not catalogued, 97424	0	2	R	O
			Kuan Kuoshui	97524, 97525	0	2	R	O
	Dicaeidae	*Dicaeum concolor*	Shiwandashan	96457, 96458, 96459, 96460, 98124, 98127	0	6	R	F
	Dicruridae	*Dicrurus hottentottus*	Jing Xi	93401, 93402, 96624, 97113, 97115	0	5	R	F
			Shiwandashan	96419	0	1	R	F
		D. leucophaeus	Jing Xi	93397, 93398, 93399	0	3	M	O
	Emberizidae	*Emberiza elegans*	Dashahe	97431, 98929, 98950, 99314, 99316, 99349	0	6	M	O
			Kuan Kuoshui	97532, 97533, 97534, 97535,† 97536, 97537, 97538, 97607, 97608,† 99307	2	10	M	O
		E. godlewskii	Dashahe	97430	0	1	R	O
		E. pusilla	Dashahe	97422	0	1	M	O
			Kuan Kuoshui	97527,† 97528, 97529, 97530, 98918	1	5	M	O
			Shuipu	99401, 99859, 99860, 99861, 99862, 99965, 99981	0	7	M	O

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
		E. spodocephala	Dashahe	97429, 98939	0	2	M	O
			Kuan Kuoshui	97539, 97540, 99306	0	3	M	O
			Shuipu	99439, 99863, 99864, 99865, 99866, 110308, 1 not catalogued	0	7	M	O
		E. tristrami	Shuipu	99858	0	1	M	F
		Latoucheornis siemsseni	Shuipu	99452, 99851	0	2	M	O
		Melophus lathami	Shuipu	99849, 99850,110313	0	3	R	O
	Estrilididae	*Lonchura striata*	Shuipu	99455, 99456, 99840, 99841, 99842, 99843, 99844, 99845, 99939, 99951, 99952, 110310, 1 not catalogued	0	13	R	O
	Fringillidae	*Carduelis sinica*	Kuan Kuoshui	97541	0	1	M	O
		Carpodacus erythrinus	Shuipu	99415, 99416, 99846, 99847, 99848, 110318	0	6	M	O
	Hirundinidae	*Hirundo daurica*	Shuipu	99748, 99749, 99750	0	3	M	O
	Laniidae	*Lanius schach*	Shuipu	99688	0	1	R	O
	Monarchidae	*Rhipidura albicollis*	Jing Xi	1 not catalogued, 93373, 93374, 93375, 96578, 98133	0	6	R	F
		Terpsiphone paradisi	Shiwandashan	96274, 96447, 96448, 96451, 96452, 96453, 96973, 97205	0	8	R	F
	Motacillidae	*Anthus hodgsoni*	Dashahe	97427, 97428	0	2	M	O
			Jing Xi	96622	0	1	M	O
			Shuipu	99421, 99429, 99781, 99782, 99783, 99964, 99967, 99971, 110306, 110329	0	10	M	O
		Motacilla alba	Jing Xi	96620, 96621	0	2	M	O
			Kuan Kuoshui	97452	0	1	M	O
			Shuipu	110312, 110331	0	2	M	O
		M. cinerea	Dashahe	97479	0	1	M	O
		M. cinerea	Jing Xi	96619†	1	1	M	O
	Muscicapidae	*Brachypteryx montana*	Dashahe	97485†	1	1	M	F
		Copsychus saularis	Kuan Kuoshui	97522†	1	1	R	O
		Culicicapa ceylonensis	Jing Xi	93336, 93338, 98131	0	3	R	F
			Kuan Kuoshui	97542, 97543, 98945, 98950	0	4	R	F
			Shuipu	99418, 99453, 99813, 99814, 99815, 99816, 99817, 99818, 99946, 99953, 99957, 110315, 110333, 3 not catalogued	0	16	R	F
		Cyanoptila cyanomelana	Jing Xi	93333	0	1	M	F
			Shiwandashan	96520	0	1	M	F
		Cyornis banyumas	Jing Xi	93327, 93328, 93329, 93330, 93331,† 93332, 97074	1	7	R	F
			Shiwandashan	96504, 96505, 96506, 96507, 96508, 98211	0	6	R	F
			Shuipu	99457, 99699, 99700, 99968	0	4	R	F
		C. hainanus	Jing Xi	93343, 96574	0	2	R	F
			Kuan Kuoshui	97519, 97520, 97589	0	3	R	F
			Shiwandashan	96496, 96497, 96499, 96501, 96502, 96503	0	6	R	F
			Shuipu	110316, 110332	0	2	R	F
		Enicurus leschenaulti	Kuan Kuoshui	97546, 97547, 97548	0	3	R	F
			Shuipu	99408, 99805, 99806	0	3	R	F
		E. schistaceus	Jing Xi	93403, 97391	0	2	R	F
			Shiwandashan	96517, 96518, 97206	0	3	R	F
			Shuipu	99434	0	1	R	F

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
		Eumyias thalassina	Dashahe	97499	0	1	M	O
			Kuan Kuoshui	97523	0	1	M	O
		Ficedula hyperythra	Shiwandashan	96498	0	1	R	F
		F. mugimaki	Shuipu	99704	0	1	M	O
		F. parva	Jing Xi	93345	0	1	M	O
			Shiwandashan	96548	0	1	M	O
			Shuipu	99403, 99404	0	2	M	O
		F. tricolor	Kuan Kuoshui	97471	0	1	M	O
			Shuipu	99406, 99705	0	2	M	O
		F. zanthopygia	Shiwandashan	96549, 96550	0	2	M	O
		Luscinia cyane	Jing Xi	93348	0	1	M	F
		L. sibilans	Shuipu	99703	0	1	M	F
		Muscicapa ferruginea	Jing Xi	93370, 93371, 97109, 98143	0	4	M	F
		M. muttui	Dashahe	97496, 97497, 97498	0	3	M	F
			Jing Xi	93369, 96571, 97476	0	3	M	F
			Shiwandashan	96493, 96494	0	2	M	F
			Shuipu	99702	0	1	M	F
		Myiomela leucura	Kuan Kuoshui	97549, 97550, 97551, 99341	0	4	R	F
			Shiwandashan	96519, 96521	0	2	R	F
		Myophonus caeruleus	Jing Xi	96396	0	1	R	F
			Kuan Kuoshui	97521	0	1	R	F
			Shuipu	99831, 99832, 99936, 99970	0	4	R	F
		Niltava davidi	Dashahe	97514	0	1	M	F
			Kuan Kuoshui	1 not catalogued, 97515, 97516, 97517, 99310, 99340	0	6	M	F
			Shuipu	99692,† 99693, 99694, 99695, 99695, 99696, 99697, 99698, 110335	1	9	M	F
		N. grandis	Jing Xi	93339, 93340, 96577, 98219	0	4	M	F
		N. macgrigoriae	Jing Xi	3 not catalogued, 93342, 96580, 96581,† 96583, 97079, 97080, 98138	1	10	R	F
			Shiwandashan	96509	0	1	R	F
		Phoenicurus auroreus	Dashahe	99361	0	1	M	O
			Kuan Kuoshui	97544, 97545	0	2	M	O
		Rhyacornis fuliginosus	Dashahe	97489, 97491, 97492, 97493, 97494, 97495, 97624, 98930, 99312, 99352†	1	10	R	F
			Shiwandashan	96513, 96514	0	2	R	F
		Saxicola ferrea	Dashahe	97500	0	1	M	O
			Jing Xi	96588	0	1	M	O
			Shuipu	99411	0	1	M	O
		Zoothera citrina	Jing Xi	93407, 93408	0	2	M	F
			Shiwandashan	96387, 96388, 96391, 96392	0	4	M	F
			Shuipu	99407, 99835, 99836, 99837, 1 not catalogued	0	5	M	F
		Z. dauma	Shuipu	99833, 99834, 99937	0	3	M	F
	Nectariniidae	*Aethopyga christinae*	Shiwandashan	96462, 96463, 96465, 96466, 98122, 98210	0	6	R	O
			Shuipu	99422, 1 not catalogued	0	2	R	O
		A. gouldiae	Kuan Kuoshui	98914	0	1	R	M
		Arachnothera magna	Shiwandashan	96547	0	1	R	O
	Panuridae	*Paradoxornis alphonsianus*	Kuan Kuoshui	97450, 97470, 99303	0	3	R	F
		P. gularis	Jing Xi	96627	0	1	R	F

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
			Kuan Kuoshui	97451	0	1	R	F
		P. verreauxi	Kuan Kuoshui	97447, 97448, 97449, 97600, 97601, 98915, 99299	0	7	R	F
		P. webbianus	Dashahe	97482, 97483	0	2	R	O
			Shuipu	99440, 99766, 99767, 99768, 99769, 99962	0	6	R	O
	Paridae	*Melanochlora sultanea*	Jing Xi	93412	0	1	R	F
		Parus major	Kuan Kuoshui	97463, 98911	0	2	R	O
			Shuipu	99412, 99757, 99758, 99959	0	4	R	O
		P. monticolus	Dashahe	97484, 99313	0	2	R	O
			Kuan Kuoshui	97464, 97465, 97466, 97467, 97468, 97588, 97595, 97596, 97597, 98907, 99301, 99308, 99309, 99311, 99335, 99348	0	16	R	O
		P. venustulus	Shuipu	99432, 99754, 99755, 99756, 99940, 99960	0	6	R	O
		Sylviparus modestus	Kuan Kuoshui	97469,† 97605	1	2	R	F
	Passeridae	*Passer rutilans*	Dashahe	97425†	1	1	R	O
			Kuan Kuoshui	97531†	1	1	R	O
			Shuipu	99425, 99425, 99426, 99853, 99854, 99855, 99856, 99857, 99972, 110305, 1 not catalogued	0	11	R	O
	Pycnonotidae	*Alophoixus pallidus*	Jing Xi	93420, 96616, 96617, 98128	0	4	R	F
			Shiwandashan	96432, 96434, 96436, 96975, 98209	0	5	R	F
		Hemixos castanonotus	Shiwandashan	96437, 96441, 96442, 96444, 97201	0	5	R	F
			Shuipu	99438, 99738, 99739, 99740, 99741, 99742, 99743, 99949, 99961, 110311, 2 not catalogued	0	12	R	F
		Hypsipetes leucocephalus	Shiwandashan	96426	0	1	R	F
			Shuipu	99745	0	1	R	F
		H. mcclellandii	Dashahe	97416, 99360	0	2	R	F
			Jing Xi	93417, 93418, 96613	0	3	R	F
			Kuan Kuoshui	97402, 97403, 97404	0	3	R	F
			Shiwandashan	96454, 96455, 96456	0	3	R	F
			Shuipu	99744, 110309, 110328, 1 not catalogued	0	4	R	F
		Pycnonotus jocosus	Jing Xi	96618	0	1	R	O
			Shiwandashan	97202, 96429, 96430	0	3	R	O
		P. sinensis	Shiwandashan	96427	0	1	R	O
			Shuipu	99728, 99729, 99730	0	3	R	O
		P. xanthorrhous	Dashahe	97417, 97418	0	2	R	O
			Kuan Kuoshui	97405	0	1	R	O
			Shuipu	99435, 99731, 99732, 99734, 99735, 99736, 99737, 99954, 110307, 2 not catalogued	0	11	R	O
		Spizixos semitorques	Dashahe	97419, 97420, 98920, 99350, 99362	0	5	R	O
			Shuipu	99417, 99427, 99428, 99718, 99719, 99720, 99721, 99722, 99723, 99724, 99727, 110314, 110325, 110334, 2 not catalogued	0	16	R	O
	Sturnidae	*Acridotheres cristatellus*	Dashahe	97423	0	1	R	O
	Sylviidae	*Cettia fortipes*	Kuan Kuoshui	1 not catalogued, 97462,† 99305	1	3	R	F
			Shuipu	99803	0	1	R	F
		Orthotomus cucullatus	Jing Xi	93356	0	1	R	O
		O. sutorius	Shiwandashan	96525	0	1	R	O
		Phylloscopus sp.	Dashahe	97366, 97367, 97368	0	3	M	F
			Shuipu	4 not catalogued	1	4	M	F

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
		P. coronatus	Shiwandashan	96540	0	1	M	F
			Jing Xi	96560	0	1	M	F
		P. fuscatus	Shiwandashan	96542	0	1	M	F
		P. inornatus	Kuan Kuoshui	97365	0	1	M	F
			Shuipu	99822	0	1	M	F
		P. proregulus	Shuipu	99819, 99820, 99821	0	3	M	F
		P. reguloides	Dashahe	98928,† 97364, 97615, 97616, 97617, 98932	1	6	M	F
			Jing Xi	96559,† 96555, 96556, 96557, 96558	1	5	M	F
			Kuan Kuoshui	97359, 97361, 97362	0	3	M	F
			Shuipu	99823, 99825, 99824, 99826	0	4	M	F
		P. ricketti	Jing Xi	93362, 93363, 93364, 93365, 96954, 98137	0	6	M	F
			Shiwandashan	96527, 96528, 98126	0	3	M	F
		P. schwarzi	Kuan Kuoshui	97369†	1	1	M	F
		P. tenellipes	Jing Xi	93361, 96553	0	2	M	F
			Shiwandashan	96541, 96543, 96544, 96546	0	4	M	F
		Prinia atrogularis	Shiwandashan	96523, 96524	0	2	R	O
			Shuipu	99807	0	1	R	O
		P. inornata	Shuipu	99809	0	1	R	O
		Seicercus sp.	Kuan Kuoshui	97611, 97612, 98475	0	3	R	F
			Dashahe	97613, 97614	0	2	R	F
		S. burkii	Dashahe	98912, 98920, 98921, 98923, 98924, 98925, 98926, 98927, 99355	0	9	R	F
			Jing Xi	93355, 96566, 96568, 97073, 97377, 4 not catalogued	0	9	R	F
			Kuan Kuoshui	97370, 97371, 97372, 97373, 98906, 98909, 99337, 99344	0	8	R	F
			Shiwandashan	96531	0	1	R	F
		S. affinis	Shuipu	99827, 99828, 99829, 99830, 1 not catalogued	0	5	M	F
		S. castaniceps	Kuan Kuoshui	97459, 97460	0	2	R	F
		S. poliogenys	Jing Xi	93352, 93353	0	2	R	F
		Tesia cyaniventer	Jing Xi	93357, 93358, 93359, 96561, 97110	0	5	R	F
		Urosphena squameiceps	Jing Xi	93366, 93367, 96563	0	3	M	F
	Timaliidae	*Alcippe chrysotis*	Dashahe	97434	0	1	R	F
			Kuan Kuoshui	97435, 97436, 97437, 97440, 97604, 98905, 99298	0	7	R	F
		A. dubia	Dashahe	97477	0	1	R	F
			Shuipu	99402	0	1	R	F
		A. morrisonia	Dashahe	98935, 99318, 99356, 99357	0	4	R	F
			Jing Xi	93377, 93378, 93379, 93380, 96589, 5 not catalogued	0	10	R	F
			Kuan Kuoshui	97441, 97442, 97443, 97444, 97445, 97446, 97583, 97585, 97586,† 97593, 97594, 98916, 98917, 99297, 99300,† 99304, 99338, 99339, 2 not catalogued	2	20	R	F
			Shiwandashan	96471, 98125	0	2	R	F
			Shuipu	99442, 99443, 99444, 99445, 99446, 99449, 99706, 99707, 99708, 99709, 99710, 99711, 99712, 99713, 99714, 99715, 99717, 16 not catalogued	0	33	R	F

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
		Babax lanceolotus	Dashahe	97501, 97502, 97623, 98941	0	4	R	O
		Garrulax canorus	Shiwandashan	1 not catalogued	0	1	R	O
		G. chinensis	Jing Xi	96400	0	1	R	F
			Shiwandashan	96401	0	1	R	F
		G. cineraceus	Kuan Kuoshui	97566, 97567,† 97590, 98948	1	4	R	F
			Shuipu	99420, 99751, 99752, 99753	0	4	R	F
		G. milnei	Jing Xi	93390	0	1	R	F
			Kuan Kuoshui	97555, 97556, 97557, 97558, 97559, 97560, 97561, 97562, 97563, 97609	0	10	R	F
		G. ocellatus	Dashahe	97504	0	1	R	F
		G. pectoralis	Kuan Kuoshui	97554, 99343	0	2	R	F
		G. poecilorhynchus	Kuan Kuoshui	97552, 97553, 97610	0	3	R	F
		G. sannio	Kuan Kuoshui	97568, 97569, 97570	0	3	R	O
			Shuipu	99414	0	1	R	O
		Minla cyanouroptera	Dashahe	97505	0	1	R	F
			Kuan Kuoshui	97572, 97573, 97587, 97599, 98951, 99346	0	6	R	F
		M. ignotincta	Dashahe	97506, 97507	0	2	R	F
			Kuan Kuoshui	97571	0	1	R	F
		Napothera brevicaudata	Jing Xi	93349, 93350, 93351, 96607, 96608, 97392	0	6	R	F
			Shiwandashan	96484	0	1	R	F
		Pellorneum albiventre	Jing Xi	93321, 93323, 96610	0	3	R	F
			Shiwandashan	96974	0	1	R	F
		P. tickelli	Jing Xi	93324	0	1	R	F
		Pomatorhinus ruficollis	Dashahe	97511, 97512, 97513	0	3	R	F
			Jing Xi	93413, 93414, 93415, 96592, 97390, 98144	0	6	R	F
			Kuan Kuoshui	97370, 97576, 97578, 97579, 97580, 97581, 97582, 99333, 1 not catalogued	0	9	R	F
			Shiwandashan	96475, 96476, 96476	0	3	R	F
			Shuipu	99451, 99770,† 99771, 99772, 99773, 99774, 99775, 99777, 99778, 99779, 99780, 2 not catalogued	1	13	R	F
		Pteruthius flaviscapis	Jing Xi	93410	0	1	R	F
		Stachyris nigriceps	Jing Xi	93382, 96593 96594, 96597, 96598, 96599, 96983, 97070, 97108,† 98129, 98215, 98216, 98217, 6 not catalogued	1	19	R	F
		S. ruficeps	Dashahe	99358	0	1	R	F
			Jing Xi	93385	0	1	R	F
			Kuan Kuoshui	97455, 97456, 98919, 99318, 99342, 99356, 99356, 1 not catalogued	0	8	R	F
			Shiwandashan	6 not catalogued	0	6	R	F
			Shuipu	99419, 99430, 99431, 99790, 99791, 99792, 99793, 99794, 99795, 99796, 99797, 99798, 99947, 110327, 3 not catalogued	0	17	R	F
		S. striolata	Jing Xi	93383, 93384, 96600, 96603, 96605, 2 not catalogued	0	7	R	F
			Shiwandashan	96481	0	1	R	F
		Yuhina castaniceps	Shiwandashan	96535, 96536, 96537, 96538, 96539, 98213	0	6	R	F
			Shuipu	99410, 99799, 99800, 110330	0	4	R	F
		Y. diademata	Kuan Kuoshui	97574	0	1	R	O

Order	Family	Scientific name	Site	KUNHM	No. positive	Sample	Status	Location
		Y. nigrimenta	Dashahe	97508, 99360	0	2	R	O
			Kuan Kuoshui	97575, 99347	0	2	R	O
			Shuipu	99969	0	1	R	O
		Y. zantholeuca	Jing Xi	93387, 93388, 93389, 97069, 97117, 98139, 98142, 1 not catalogued	0	8	R	F
			Shiwandashan	96532, 96533, 96534	0	3	R	F
			Shuipu	99801, 99802	0	2	R	F
	Turdidae	*Turdus dissimilis*	Shuipu	99413, 99838	0	2	R	O
	Zosteropidae	*Zosterops japonicus*	Kuan Kuoshui	98952†	1	1	M	O
			Shiwandashan	96551	0	1	M	O
			Shuipu	99448, 99784, 99786, 99787, 99788, 99789, 99938, 110317, 110336, 2 not catalogued	0	11	M	O
Piciformes	Capitonidae	*Megalaima franklinii*	Shiwandashan	96405	0	1	R	F
	Picidae	*Dendrocopos canicapillus*	Kuan Kuoshui	97410	0	1	R	F
			Shuipu	99682	0	1	R	F
		Picumnus innominatus	Dashahe	97412	0	1	R	F
			Kuan Kuoshui	97411, 97591, 98947	0	3	R	F
			Shuipu	99405, 99678, 99679, 99680, 99966	0	5	R	F
		Picus canus	Kuan Kuoshui	97408, 97409	0	2	R	F
		Sasia ochracea	Jing Xi	93394, 93395, 93396, 96630, 97111	0	5	R	F
			Shiwandashan	96413, 96415, 96416, 98208	0	4	R	F
			Shuipu	99437, 99681, 99942, 99942, 99958	0	5	R	F
Podicipediformes	Podicipedidae	*Tachybaptus ruficollis*	Kuan Kuoshui	97401	0	1	M	O
Trogoniformes	Trogonidae	*Harpactes erythrocephalus*	Jing Xi	93311	0	1	R	F

*The Kansas University Natural History Museum (KUNHM) provided the permanent catalog number of the specimen to which the individual specimen can be referred. M, migratory; O, open country; R, resident; F, forested; not catalogued, specimens not catalogued at KUNHM.
†Individual birds infected with avian influenza virus.