

List of supplementary material

Section 1: Citizen science data collection for bird species

Table S1

Bird data collected from public citizen science websites. A total of 311 bird species data were collected, and bird species with occurrence counts less than or equal to 5 were excluded when applying the RF model [1]. The classification of phenological status was based on the method proposed by Zheng et al. [2], which includes the following categories: RB (Resident birds), SMB (Summer migratory birds), WMB (Winter migratory birds), and TB (Transit birds). IUCN: International Union for Conservation of Nature, divided into five levels, LC(Least Concern); NT(Near Threatened); VU(Vulnerable); EN(Endangered); CR(Critically Endangered).

Bird species	Number of occurrences	IUCN category	Phenological status
<i>Abroscopus albogularis</i>	19	LC	RB
<i>Accipiter gentilis</i>	4	LC	WMB
<i>Accipiter gularis</i>	8	LC	WMB
<i>Accipiter nisus</i>	12	LC	WMB
<i>Accipiter soloensis</i>	18	LC	RB
<i>Accipiter trivirgatus</i>	48	LC	RB
<i>Acridotheres cristatellus</i>	454	LC	RB
<i>Acrocephalus bistrigiceps</i>	6	LC	TB
<i>Acrocephalus orientalis</i>	12	LC	SMB
<i>Actitis hypoleucos</i>	56	LC	WMB
<i>Aegithalos concinnus</i>	81	LC	RB
<i>Aegithalos glaucogularis</i>	58	LC	RB
<i>Aerodramus brevirostris</i>	2	LC	TB
<i>Aix galericulata</i>	70	LC	WMB
<i>Alauda arvensis</i>	6	LC	WMB
<i>Alauda gulgula</i>	14	LC	RB
<i>Alcedo atthis</i>	154	LC	RB
<i>Amaurornis phoenicurus</i>	50	LC	RB
<i>Anas acuta</i>	10	LC	WMB
<i>Anas platyrhynchos</i>	85	LC	WMB
<i>Anas zonorhyncha</i>	205	LC	WMB
<i>Anser fabalis</i>	2	LC	WMB
<i>Anthus cervinus</i>	12	LC	WMB
<i>Anthus gustavi</i>	4	LC	TB
<i>Anthus hodgsoni</i>	221	LC	WMB
<i>Anthus richardi</i>	18	LC	SMB
<i>Anthus rubescens</i>	13	LC	WMB
<i>Anthus spinoletta</i>	3	LC	WMB
<i>Antigone vipio</i>	1	LC	WMB
<i>Apus nipalensis</i>	11	LC	SMB
<i>Ardea alba</i>	74	LC	SMB

<i>Ardea cinerea</i>	155	LC	RB
<i>Ardea intermedia</i>	36	LC	SMB
<i>Ardea purpurea</i>	7	LC	SMB
<i>Ardeola bacchus</i>	82	LC	SMB
<i>Arenaria interpres</i>	1	LC	TB
<i>Arundinax aedon</i>	1	LC	TB
<i>Asio flammeus</i>	3	LC	WMB
<i>Asio otus</i>	3	LC	WMB
<i>Aythya baeri</i>	7	CR	WMB
<i>Aythya ferina</i>	18	VU	WMB
<i>Aythya fuligula</i>	104	LC	WMB
<i>Aythya marila</i>	3	LC	WMB
<i>Bombycilla garrulus</i>	17	LC	WMB
<i>Bombycilla japonica</i>	15	NT	WMB
<i>Botaurus stellaris</i>	5	LC	WMB
<i>Bubulcus coromandus</i>	26	/	SMB
<i>Bucephala clangula</i>	1	LC	WMB
<i>Butastur indicus</i>	9	LC	TB
<i>Buteo japonicus</i>	39	LC	WMB
<i>Butorides striata</i>	23	LC	RB
<i>Calcarius lapponicus</i>	1	LC	WMB
<i>Calidris acuminata</i>	7	LC	TB
<i>Calidris alba</i>	4	LC	TB
<i>Calidris alpina</i>	7	LC	WMB
<i>Calidris canutus</i>	2	NT	TB
<i>Calidris falcinellus</i>	2	LC	TB
<i>Calidris minuta</i>	1	LC	TB
<i>Calidris pugnax</i>	1	LC	TB
<i>Calidris pygmaea</i>	3	CR	WMB
<i>Calidris ruficollis</i>	10	NT	TB
<i>Calidris subminuta</i>	3	LC	TB
<i>Calidris temminckii</i>	3	LC	WMB
<i>Calidris tenuirostris</i>	3	EN	TB
<i>Calliope calliope</i>	8	LC	TB
<i>Caprimulgus jotaka</i>	23	LC	SMB
<i>Cecropis daurica</i>	26	LC	TB
<i>Centropus bengalensis</i>	6	LC	RB
<i>Ceryle rudis</i>	5	LC	RB
<i>Charadrius alexandrinus</i>	21	LC	TB
<i>Charadrius dubius</i>	21	LC	TB
<i>Charadrius leschenaultii</i>	8	LC	TB
<i>Charadrius mongolus</i>	3	LC	TB
<i>Charadrius veredus</i>	5	LC	TB
<i>Chlidonias hybrida</i>	10	LC	TB

<i>Chlidonias leucopterus</i>	5	LC	WMB
<i>Chloris sinica</i>	157	LC	RB
<i>Chroicocephalus ridibundus</i>	43	LC	WMB
<i>Circus cyaneus</i>	2	LC	WMB
<i>Circus melanoleucos</i>	1	LC	WMB
<i>Circus spilonotus</i>	1	LC	WMB
<i>Cisticola juncidis</i>	20	LC	RB
<i>Clamator coromandus</i>	7	LC	RB
<i>Coccothraustes coccothraustes</i>	20	LC	WMB
<i>Copsychus saularis</i>	479	LC	RB
<i>Corvus corone</i>	1	LC	WMB
<i>Corvus frugilegus</i>	8	LC	RB
<i>Corvus macrorhynchos</i>	1	LC	RB
<i>Coturnix japonica</i>	2	NT	WMB
<i>Cuculus canorus</i>	21	LC	SMB
<i>Cuculus micropterus</i>	58	LC	SMB
<i>Cuculus poliocephalus</i>	3	LC	SMB
<i>Cuculus saturatus</i>	1	LC	SMB
<i>Culicicapa ceylonensis</i>	10	LC	SMB
<i>Cyanopica cyanus</i>	388	LC	RB
<i>Cyanoptila cyanomelana</i>	42	LC	TB
<i>Cygnus columbianus</i>	1	LC	WMB
<i>Cygnus cygnus</i>	1	LC	WMB
<i>Cygnus olor</i>	1	LC	TB
<i>Delichon dasypus</i>	7	LC	TB
<i>Dendrocitta formosae</i>	4	LC	RB
<i>Dendrocopos major</i>	23	LC	RB
<i>Dendronanthus indicus</i>	6	LC	TB
<i>Dicrurus hottentottus</i>	3	LC	SMB
<i>Dicrurus leucophaeus</i>	6	LC	SMB
<i>Dicrurus macrocercus</i>	17	LC	SMB
<i>Egretta eulophotes</i>	5	VU	SMB
<i>Egretta garzetta</i>	432	LC	SMB
<i>Elanus caeruleus</i>	3	LC	RB
<i>Emberiza chrysophrys</i>	37	LC	TB
<i>Emberiza cioides</i>	1	LC	RB
<i>Emberiza elegans</i>	130	LC	WMB
<i>Emberiza fucata</i>	5	LC	TB
<i>Emberiza pallasi</i>	16	LC	TB
<i>Emberiza pusilla</i>	17	LC	WMB
<i>Emberiza rustica</i>	26	VU	WMB
<i>Emberiza rutila</i>	7	LC	TB
<i>Emberiza spodocephala</i>	250	LC	WMB
<i>Emberiza tristrami</i>	113	LC	WMB

<i>Emberiza yessoensis</i>	2	NT	WMB
<i>Eophona personata</i>	43	LC	WMB
<i>Eudynamys scolopaceus</i>	13	LC	SMB
<i>Eumyias thalassinus</i>	17	LC	SMB
<i>Eurystomus orientalis</i>	31	LC	TB
<i>Falco amurensis</i>	5	LC	WMB
<i>Falco columbarius</i>	1	LC	WMB
<i>Falco peregrinus</i>	53	LC	WMB
<i>Falco subbuteo</i>	8	LC	SMB
<i>Falco tinnunculus</i>	76	LC	WMB
<i>Ficedula albicilla</i>	18	LC	TB
<i>Ficedula mugimaki</i>	77	LC	TB
<i>Ficedula narcissina</i>	27	LC	TB
<i>Ficedula zanthopygia</i>	30	LC	SMB
<i>Fringilla montifringilla</i>	126	LC	WMB
<i>Fulica atra</i>	202	LC	WMB
<i>Gallinago gallinago</i>	30	LC	WMB
<i>Gallinago megala</i>	2	LC	TB
<i>Gallinago stenura</i>	5	LC	TB
<i>Gallinula chloropus</i>	210	LC	RB
<i>Gavia arctica</i>	15	LC	WMB
<i>Gavia stellata</i>	6	LC	WMB
<i>Gelochelidon nilotica</i>	2	LC	RB
<i>Geokichla sibirica</i>	10	LC	TB
<i>Glareola maldivarum</i>	5	LC	TB
<i>Gracupica nigricollis</i>	67	LC	RB
<i>Grus grus</i>	1	LC	WMB
<i>Halcyon pileata</i>	3	LC	SMB
<i>Haliaeetus albicilla</i>	1	LC	WMB
<i>Helopsaltes ochotensis</i>	3	LC	TB
<i>Helopsaltes pryeri</i>	4	NT	WMB
<i>Hemixos castanonotus</i>	5	LC	RB
<i>Hierococyx hyperythrus</i>	3	LC	WMB
<i>Himantopus himantopus</i>	12	LC	TB
<i>Hirundapus caudacutus</i>	1	LC	TB
<i>Hirundo rustica</i>	239	LC	SMB
<i>Horornis canturians</i>	36	LC	SMB
<i>Horornis fortipes</i>	10	LC	RB
<i>Hydrophasianus chirurgus</i>	6	LC	SMB
<i>Hydroprogne caspia</i>	3	LC	SMB
<i>Hypothymis azurea</i>	3	LC	RB
<i>Hypsipetes amaurotis</i>	7	LC	TB
<i>Hypsipetes leucocephalus</i>	9	LC	SMB
<i>Ichthyaetus ichthyaetus</i>	6	LC	TB

<i>Ixobrychus cinnamomeus</i>	2	LC	SMB
<i>Ixobrychus eurhythmus</i>	1	LC	SMB
<i>Ixobrychus flavicollis</i>	3	LC	SMB
<i>Ixobrychus sinensis</i>	39	LC	SMB
<i>Jynx torquilla</i>	5	LC	WMB
<i>Lalage melaschistos</i>	9	LC	SMB
<i>Lanius bucephalus</i>	8	LC	WMB
<i>Lanius cristatus</i>	48	LC	SMB
<i>Lanius sphenocercus</i>	5	LC	WMB
<i>Lanius tigrinus</i>	12	LC	SMB
<i>Larus canus</i>	28	LC	WMB
<i>Larus crassirostris</i>	20	LC	WMB
<i>Larus fuscus</i>	41	LC	WMB
<i>Larus glaucescens</i>	7	LC	WMB
<i>Larus schistisagus</i>	16	LC	WMB
<i>Larus vegae</i>	108	/	WMB
<i>Larvivora akahige</i>	2	LC	TB
<i>Larvivora cyane</i>	10	LC	TB
<i>Larvivora sibilans</i>	27	LC	TB
<i>Leucogeranus leucogeranus</i>	1	CR	WMB
<i>Limnodromus scolopaceus</i>	1	LC	TB
<i>Limosa lapponica</i>	6	NT	TB
<i>Limosa limosa</i>	6	NT	TB
<i>Locustella lanceolata</i>	3	LC	TB
<i>Lonchura punctulata</i>	42	LC	RB
<i>Lonchura striata</i>	145	LC	RB
<i>Luscinia svecica</i>	11	LC	TB
<i>Macropygia unchall</i>	13	LC	RB
<i>Mareca falcata</i>	27	NT	WMB
<i>Mareca penelope</i>	7	LC	WMB
<i>Mareca strepera</i>	51	LC	WMB
<i>Mergellus albellus</i>	2	LC	WMB
<i>Mergus merganser</i>	1	LC	WMB
<i>Milvus migrans</i>	6	LC	RB
<i>Monticola gularis</i>	7	LC	TB
<i>Monticola solitarius</i>	5	LC	RB
<i>Motacilla alba</i>	765	LC	RB
<i>Motacilla cinerea</i>	73	LC	TB
<i>Motacilla citreola</i>	1	LC	WMB
<i>Motacilla tschutschensis</i>	42	LC	TB
<i>Muscicapa dauurica</i>	76	LC	TB
<i>Muscicapa griseisticta</i>	40	LC	TB
<i>Muscicapa sibirica</i>	28	LC	TB
<i>Myophonus caeruleus</i>	2	LC	SMB

<i>Nettapus coromandelianus</i>	4	LC	SMB
<i>Niltava davidi</i>	1	LC	SMB
<i>Ninox japonica</i>	6	LC	WMB
<i>Numenius arquata</i>	4	NT	WMB
<i>Numenius madagascariensis</i>	5	EN	TB
<i>Numenius minutus</i>	3	LC	TB
<i>Numenius phaeopus</i>	7	LC	TB
<i>Nycticorax nycticorax</i>	893	LC	RB
<i>Onychoprion anaethetus</i>	1	LC	SMB
<i>Oriolus chinensis</i>	26	LC	SMB
<i>Pandion haliaetus</i>	7	LC	RB
<i>Paradoxornis heudei</i>	12	NT	RB
<i>Parus minor</i>	389	/	RB
<i>Passer montanus</i>	1145	LC	RB
<i>Pelecanus crispus</i>	2	NT	TB
<i>Pericrocotus cantonensis</i>	8	LC	SMB
<i>Pericrocotus divaricatus</i>	16	LC	TB
<i>Periparus ater</i>	6	LC	RB
<i>Pernis ptilorhynchus</i>	7	LC	TB
<i>Phalacrocorax carbo</i>	65	LC	WMB
<i>Phalaropus lobatus</i>	5	LC	TB
<i>Phasianus colchicus</i>	36	LC	RB
<i>Phoenicurus aureus</i>	285	LC	WMB
<i>Phylloscopus borealis</i>	44	LC	TB
<i>Phylloscopus castaniceps</i>	1	LC	SMB
<i>Phylloscopus coronatus</i>	43	LC	TB
<i>Phylloscopus fuscatus</i>	18	LC	WMB
<i>Phylloscopus inornatus</i>	135	LC	WMB
<i>Phylloscopus plumbeitarsus</i>	5	LC	TB
<i>Phylloscopus proregulus</i>	256	LC	WMB
<i>Picumnus innominatus</i>	19	LC	RB
<i>Platalea leucorodia</i>	2	LC	TB
<i>Platalea minor</i>	3	EN	TB
<i>Plegadis falcinellus</i>	2	LC	TB
<i>Pluvialis fulva</i>	9	LC	TB
<i>Pluvialis squatarola</i>	2	LC	TB
<i>Podiceps auritus</i>	1	VU	WMB
<i>Podiceps cristatus</i>	29	LC	WMB
<i>Podiceps nigricollis</i>	2	LC	WMB
<i>Poecile palustris</i>	3	LC	RB
<i>Prinia inornata</i>	61	LC	RB
<i>Pterorhinus perspicillatus</i>	50	LC	RB
<i>Pycnonotus sinensis</i>	748	LC	RB
<i>Pycnonotus xanthorrhous</i>	1	LC	RB

<i>Rallus indicus</i>	11	LC	WMB
<i>Recurvirostra avosetta</i>	4	LC	TB
<i>Regulus regulus</i>	41	LC	WMB
<i>Remiz consobrinus</i>	30	LC	WMB
<i>Riparia diluta</i>	2	LC	RB
<i>Rostratula benghalensis</i>	2	LC	RB
<i>Saxicola stejnegeri</i>	18	/	WMB
<i>Scolopax rusticola</i>	26	LC	WMB
<i>Sinosuthora webbiana</i>	215	LC	RB
<i>Sittiparus varius</i>	6	LC	RB
<i>Spatula clypeata</i>	8	LC	WMB
<i>Spatula querquedula</i>	7	LC	TB
<i>Spilopelia chinensis</i>	817	LC	RB
<i>Spinus spinus</i>	134	LC	WMB
<i>Spizixos semitorques</i>	21	LC	RB
<i>Spodiopsar cineraceus</i>	352	LC	WMB
<i>Spodiopsar sericeus</i>	247	LC	RB
<i>Sterna hirundo</i>	20	LC	TB
<i>Sternula albifrons</i>	6	LC	SMB
<i>Streptopelia orientalis</i>	175	LC	RB
<i>Streptopelia tranquebarica</i>	15	LC	RB
<i>Sturnus vulgaris</i>	2	LC	TB
<i>Tachybaptus ruficollis</i>	199	LC	RB
<i>Tadorna ferruginea</i>	1	LC	WMB
<i>Tadorna tadorna</i>	3	LC	WMB
<i>Tarsiger cyanurus</i>	307	LC	WMB
<i>Terpsiphone atrocaudata</i>	10	NT	TB
<i>Terpsiphone incei</i>	3	LC	SMB
<i>Thalasseus bernsteini</i>	5	CR	SMB
<i>Treron sieboldii</i>	4	LC	TB
<i>Tringa brevipes</i>	3	NT	TB
<i>Tringa erythropus</i>	6	LC	TB
<i>Tringa glareola</i>	14	LC	TB
<i>Tringa guttifer</i>	1	EN	TB
<i>Tringa nebularia</i>	12	LC	WMB
<i>Tringa ochropus</i>	24	LC	WMB
<i>Tringa stagnatilis</i>	9	LC	TB
<i>Tringa totanus</i>	8	LC	TB
<i>Troglodytes troglodytes</i>	2	LC	RB
<i>Turdus cardis</i>	25	LC	TB
<i>Turdus chrysolaus</i>	4	LC	SMB
<i>Turdus eunomus</i>	136	LC	WMB
<i>Turdus hortulorum</i>	175	LC	WMB
<i>Turdus mandarinus</i>	1293	LC	RB

<i>Turdus mupinensis</i>	2	LC	RB
<i>Turdus naumanni</i>	57	LC	WMB
<i>Turdus obscurus</i>	51	LC	TB
<i>Turdus pallidus</i>	262	LC	WMB
<i>Turdus ruficollis</i>	7	LC	WMB
<i>Turnix tanki</i>	1	LC	SMB
<i>Upupa epops</i>	125	LC	RB
<i>Urosphena squameiceps</i>	15	LC	TB
<i>Vanellus cinereus</i>	4	LC	SMB
<i>Vanellus vanellus</i>	4	NT	WMB
<i>Xenus cinereus</i>	8	LC	TB
<i>Yuhina torqueola</i>	1	LC	RB
<i>Yungipicus canicapillus</i>	6	LC	RB
<i>Zoothera aurea</i>	99	LC	WMB
<i>Zosterops erythropleurus</i>	5	LC	TB
<i>Zosterops japonicus</i>	8	LC	SMB

Section 2: Authenticity verification of citizen science data through observational data

Table S2

Area and location information of 20 survey sites. The latitude and longitude information donates the coordinates of the central point of the site.

Site ID	Site name	Area(hm ²)	Latitude	Longitude
S1	Yangpu Park	20.23	31.282476	121.531938
S2	Peace Park	16.07	31.272752	121.498739
S3	Luxun Park	22.74	31.273735	121.479042
S4	Quyang Park	6.50	31.289065	121.482053
S5	Jingan Park	2.75	31.223870	121.442182
S6	Yanzhong Plaza	5.06	31.227490	121.470490
S7	Gucheng park	3.37	31.230485	121.489350
S8	Xujiahui Park	7.94	31.199265	121.437869
S9	Fuxing Park	7.32	31.218942	121.464586
S10	Zhabei Park	12.00	31.272295	121.455310
S11	Binjiang Park	10.10	31.244795	121.497766
S12	Taipingqiao Park	2.09	31.221378	121.472248
S13	Shanghai Cultural Square	9.88	31.213912	121.458458
S14	Bright City Greenland	4.17	31.246562	121.455960
S15	Renming Rd Greenland	1.42	31.230780	121.484501
S16	Qinjian Chunyuan	5.41	31.197335	121.489622
S17	Nanyuan Waterfront Green Park	10.66	31.193703	121.471115
S18	Huangpu Park	1.97	31.243866	121.486316
S19	Zhongshan East 2Rd Greenland	2.26	31.230717	121.491275
S20	Nansuzhou Rd Greenland	3.39	31.244422	121.484497

Bird data collected from field observations. * represents citizen science data of bird species.

[illegible]

[illegible]

Table S4

Comparison between observational data and citizen science data. Species repetition rate refers to the ratio of the richness of species observed both in the field and through citizen science, to the total richness of species observed in the field and through citizen science in a given site.

Site ID	Bird richness (observational data)	Bird richness (citizen science data)	Species repetition rate
S1	9	8	0.70
S2	5	4	0.80
S3	16	18	0.70
S4	7	8	0.67
S5	8	8	1.00
S6	9	10	0.58
S7	15	23	0.65
S8	18	22	0.74
S9	12	15	0.80
S10	9	12	0.61
S11	17	17	0.74
S12	5	6	0.83
S13	8	8	0.78
S14	5	5	0.67
S15	9	8	0.70
S16	5	5	1.00
S17	12	13	0.67
S18	2	2	1.00
S19	3	3	1.00
S20	3	3	1.00

Reference

1. Belhaj, A.; Pallarés, S.; Bennis, N.; Chergui, B.; Sánchez-Fernández, D. Towards the identification of hotspots of freshwater biodiversity in North-Western Africa: A case study using species distribution models for water beetles in Morocco. *Global Ecology and Conservation* **2023**, *43*, doi:10.1016/j.gecco.2023.e02441.
2. Guangmei, Z. *A Checklist on the Classification and Distribution of the Birds of China (Third Edition)*; Science Press: Beijing, 2017.