

## PAST TRENDS, CURRENT RESEARCH AND FUTURE PERSPECTIVES OF WEST AFRICAN ORNITHOLOGY

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SYSTEMATIC REVIEW  
GOOGLE SCHOLAR  
ORNITHOLOGY  
CONSERVATION  
WEST AFRICA

**ABSTRACT.** – The bird fauna of West Africa region is of highest conservation value, including 1371 species, three primary Endemic Bird Areas (EBA), eight secondary EBAs and 331 Important Bird and Biodiversity Areas (IBAs). The aims of this review are to systematically identify and collate studies focusing on the ornithology in the region. We carried out a Google Scholar search using as keywords the habitat types available in the region (mangrove, rainforest, Guinea savannah, Sudanese savannah, Sahel), the name of the countries in the region, and six ornithological disciplinary sectors in turn ('Community Ecology', 'Taxonomy', 'Population Biology', 'Conservation Biology', 'Pollution effects', and 'Climate Change effects'). Four countries (with Nigeria on the top) were subjected to much more ornithological investigations than the other countries. Guinea, Liberia, and Sierra Leone were the least studied countries. Although the number of ornithological studies increased remarkably in the last years, the relative scientific effort remained stable across countries either before or after 2006. In terms of habitat, studies on rainforest ornithology were more numerous than studies from other habitat types. Ornithological studies by disciplinary sector showed a slight prevalence of studies on population biology and climate change effects on birds. The overall implications of the observed patterns are discussed.

### INTRODUCTION

West African sub-Saharan regions house several important ecological areas, as well as crucial hotspots and ecoregions, such as, for instance, the Guinean forests of West Africa, some of the most important mangrove formations in the world, as well as the arid and semiarid savannahs of the Sahel (Mallon *et al.* 2005). All of these biotopes contain an exceptional diversity of species of vascular plants, as well as vertebrates and invertebrates, with a large number of species that are endemic to this region (Kindon *et al.* 1990, Oates *et al.* 2004).

In the West African region, there is also a great diversity of birds species (Fig. 1; *e.g.* Okoni-Williams *et al.* 2001, Okoni-Williams 2004), including 1371 species (Mallon *et al.* 2005), three primary Endemic Bird Areas (EBA) and eight secondary EBAs (containing one restricted-range species; < 50,000 km<sup>2</sup>) (Stattersfield *et al.* 1998). In addition, many areas in West Africa are important for bird diversity and conservation, as demonstrated by the 331 Important Bird and Biodiversity Areas (IBAs) found in

the region, particularly in Ghana, Cameroon and Nigeria (Fishpool & Evans 2001). For instance, the West African Sahel has a great importance also for bird migration. Millions of birds, that breed in the northern hemisphere during summer, migrate every year between the temperate and arctic regions of northern Europe and the dry and wet tropical ecosystems of Africa, and this migration is one of the world's great long-distance animal movements. Many species take on this migration, including waterfowl, waders, birds of prey and songbirds: over 2 billions songbirds are estimated to migrate from Europe to sub-Saharan Africa each year (Hahn *et al.* 2009). Therefore, the West African Sahel region has global relevance for ornithological ecology and conservation, and does not concern merely with tropical ornithology.

A synthesis of the knowledge on the West African ornithological science is very much needed and has never been attempted to date (but see Mallon *et al.* 2005, for a short synopsis), despite the publication of dedicated field guides and of a number of technical articles, *e.g.* Gartshore *et al.* 1995, Gatter 1997, Rondeau & Thiollay



Fig. 1. – Selected bird species of West Africa: 1) *Coracias abyssinica*; 2) *Tockus nasutus*; 3) *Actophilornis africana*; 4) *Vanellus spinosus*; 5) *Polyboroides typus*; 6) *Halcyon leucocephala*; 7) *Ephippiorhynchus senegalensis*; 8) *Merops bullocki*; 9) *Scopus umbretta*; 10) *Terathopius ecaudatus*; 11) *Gypohierax angolensis*; 12) *Necrosyrtes monachus*.

2004, Thiollay 2006a, Thiollay 2006b). Indeed, studies in this region have attracted much scientific interest for tropical ecologists and conservation biologists, and much has been published in international journals and by multilateral agencies such as UNDP, UNEP, FAO, IUCN, etc. (Mallon *et al.* 2005). In the great majority of these studies and reports, birds do not represent the principal subject of investigation, but are nonetheless often mentioned with noteworthy records and observations being presented. These records and observations include data on community ecology, species diversity surveys, conservation biology (habitat selection, *e.g.* Ogada & Buij 2011;

ecotoxicology, taxonomy, distribution, *e.g.* Waltert *et al.* 2010; population biology, *e.g.* Wachter *et al.* 2013; climate change effects on birds and migration, *e.g.* Thiollay 2001; trade, *e.g.* Waugh 2010 and even ethnozoological studies, *e.g.* Saidu & Buij 2013). Nonetheless, no study is available summarizing from a quantitative point of view this diversity of studies that, focusing on West African habitats and species, may highlight the current and future trends of the ornithological science in this region of the African continent, evidencing the direct and indirect threats (*sensu* Battisti *et al.* 2016), so facilitating the definition of

project-based management and conservation strategies at species and group levels.

In this paper we (1) present the results of a systematic review on the scientific literature available on the ecology and conservation of birds in the West African region, (2) summarize some of the main sources of evidences available, discuss points of controversy, and (3) suggest possible next steps for pure and applied scientific research in the years to come.

## METHODS

A systematic review using Google Scholar (see Pomerantz 2006) was performed in order to quantify the availability of peer-reviewed scientific studies undertaken on West African ornithology. A first Google Scholar search was made on 11 January 2017, using as keywords the habitat types available in the region (mangrove, rainforest, Guinea savannah, Sudanese savannah, Sahel), the name of the countries in the region, and the following disciplinary sectors in turn: 'Community Ecology', 'Taxonomy', 'Population Biology', 'Conservation Biology', 'Pollution effects', and 'Climate Change effects'. Peer-reviewed articles published in international as well as in local journals, academic dissertations (Masters and PhD theses), books, conference proceedings, and industry/multilateral agency reports (FAO, UNDP, UNEP, IUCN, CITES, etc.) were included in the analysis. In addition, we subdivided the studies as being published before 2006 and in 2006-2017 period.

Studies were checked for relevance if they: (1) reported raw data that can be statistically analyzed (even if not mainly concerned with ornithological studies); (2) presented some explicit considerations/opinions/observations on the above-mentioned disciplinary sectors for the study region; (3) contributed data/considerations/opinions/observations that were clearly attributable to one or more of the above-mentioned vegetation zones. Contingency table  $\chi^2$  tests were used to compare two or more frequencies, using PAST 3.0 software for their calculations.

## RESULTS

The total number of results obtained for West African ornithology, by habitat, country and disciplinary sector, is given in Supplementary material S1. Overall, 792,201 results were obtained (478,850 till the end of 2005), including not only studies focusing on West African ornithology, but also more general studies that simply mention bird species in any of the considered West African countries (these latter are dominant over purely ornithological studies).

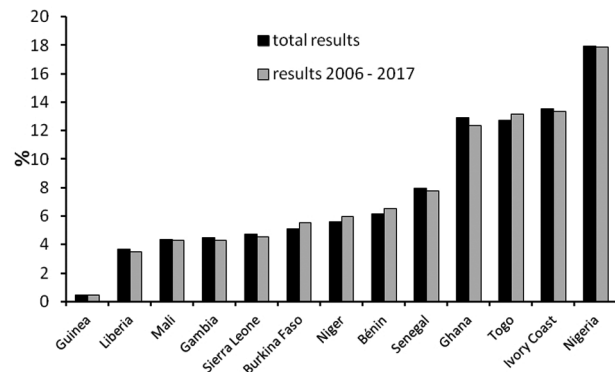


Fig. 2. – Distribution of the Google Scholar results on West African ornithology by country.

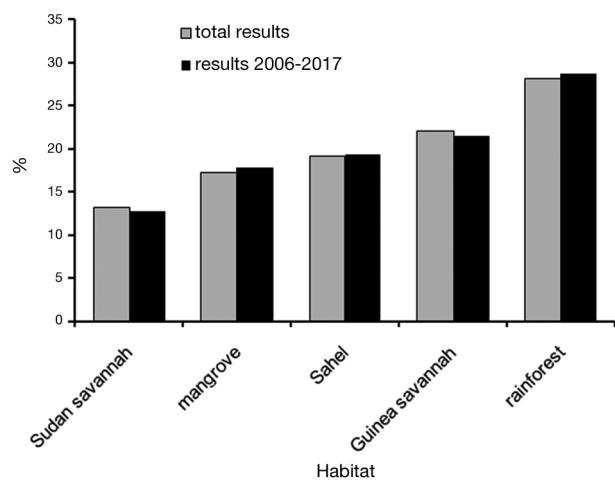


Fig. 3. – Distribution of the Google Scholar results on West African ornithology by habitat.

Four countries clearly dominated in terms of total number of results in West African ornithology: Ghana, Togo, Ivory Coast, and especially Nigeria which accounted alone for about 18 % of the total number of studies (Fig. 2). On the other side, Guinea was the least studied country from the bird study point of view (Fig. 2). The percentage differences in terms of number of published studies across countries between time periods (up to 2005 versus 2006-2016) did not differ significantly ( $\chi^2 = 0.35$ ;  $df = 1$ ;  $P > 0.9$ ), thus showing that, although the number of studies increased remarkably in the last years, the relative scientific effort remained stable across countries.

In terms of habitat, studies on rainforest ornithology were more numerous than studies from other habitat types (accounting for about 28 % of the total studies; Fig. 3), with however non-significant differences at  $\chi^2$  test, in either of the two time periods.

The distribution of studies by habitat  $\times$  country is given in Fig. 4. The comparative analysis of these data suggest that the same general patterns already observed above (*i.e.* preponderance of studies in Nigeria, Togo, Ghana and Ivory Coast) is obviously evident also in habitat  $\times$

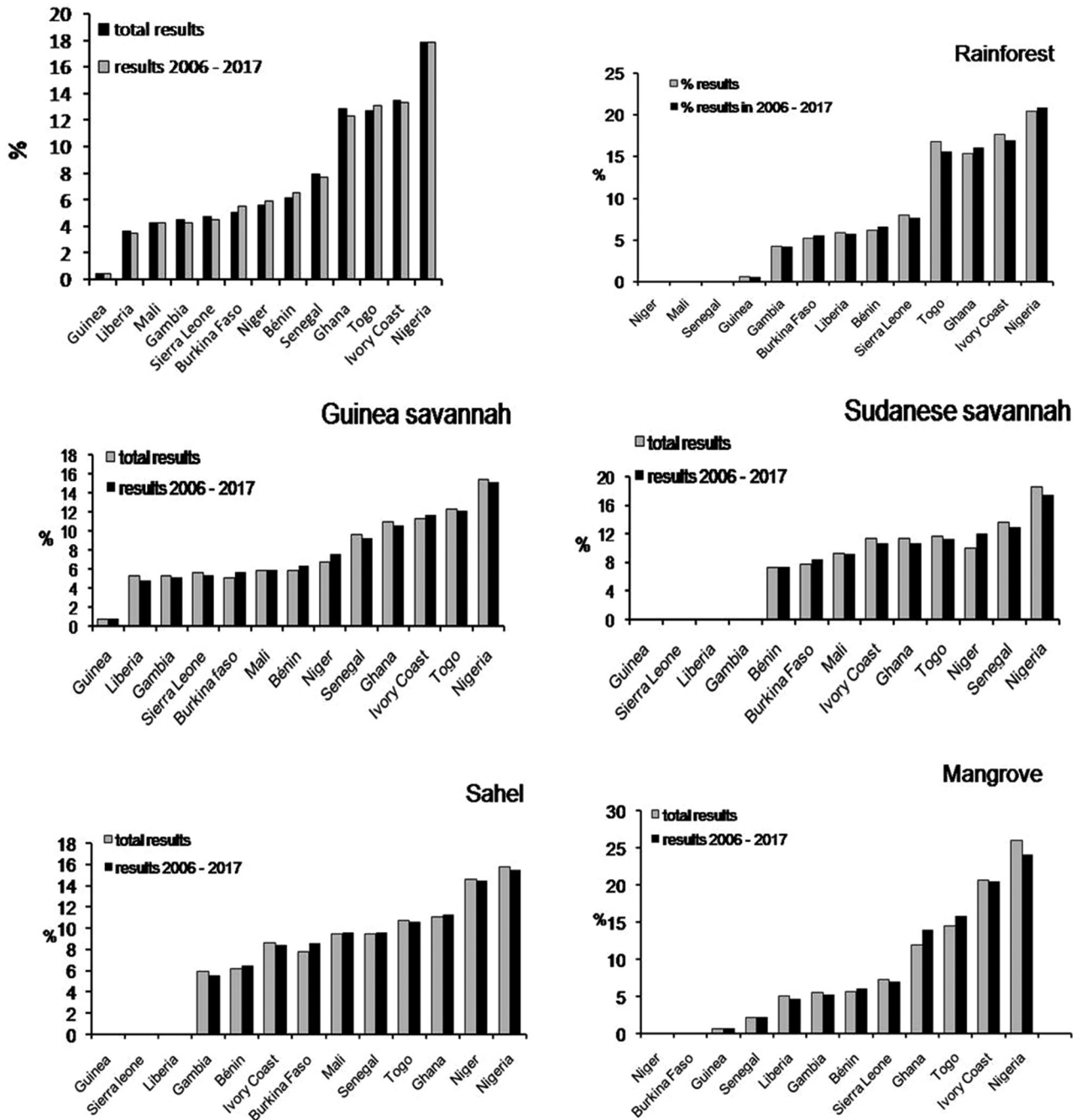


Fig. 4. – Distribution of West African ornithological studies by habitat × country

country comparisons. However, there were also differences that were clearly imputable to the almost total absence of a given habitat in a given country, and consequently the absence of studies on that habitat type in that country. For instance, ornithological studies in the mangrove ecosystem were never published for Niger and Burkina Faso (where mangrove formations do not occur), or studies in the rainforest ornithology were never published for Niger, Mali and Senegal (Fig. 4).

Ornithological studies by disciplinary sector showed a slight prevalence of studies on population biology and

climate change effects on birds over other sectors (Fig. 5), with a non-significant difference between time intervals ( $P > 0.6$  at  $\chi^2$  test).

**DISCUSSION**

The field studies on West African ecology and conservation are in strong expansion in the recent years (Mallon *et al.* 2005), especially under the impetus of the fast-growing indigenous research by local scientific institu-

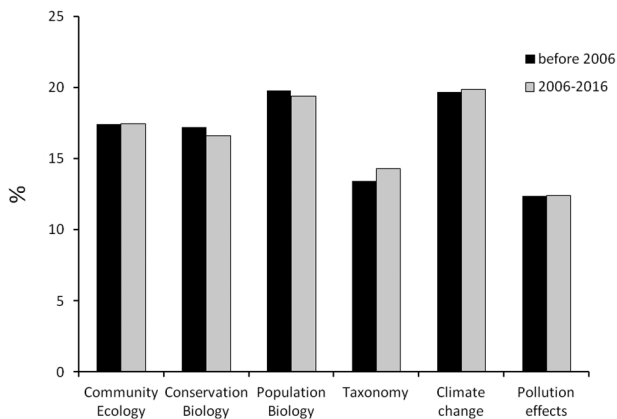


Fig. 5. – Distribution of the Google Scholar results on West African ornithology by disciplinary sector.

tions. For instance, only Nigeria houses 25 out of the 200 top ranked universities in the continent, and other countries in the region, including, *e.g.* some universities in Ghana, Ivory Coast and Burkina Faso, also rank very well in terms of scientific production (database of UniRank, for the year 2016). Ornithology is obviously inside this trend, especially because birds are usually not the primary target of scientific researches, but just model organisms in wider studies focusing on general environment, pollution, etc. Therefore, the place of ornithological studies in West Africa could not be clearly highlighted if not placing their statistics, as presented in this paper, in the wider context of environmental and conservation biology studies in the region. Indeed, the results obtained in the present study mirrored the same patterns by country as highlighted for studies in general ecology and conservation biology of West African forests (Luiselli *et al.* 2017). In addition, also the research traditions inherited from the colonial age could not be forgotten: for instance, the high rank of Togo in terms of studies can also be explained because, during the German colonization period (1884-1914), Togo included also the eastern Ghana (actual Volta Region), hence several Google Scholar results would have been assigned to Ghana had we used post-colonial political limits (*e.g.* Matschie 1899, Schwarz 1920, Owusu-Ansah 2008). In addition, the Bismarckburg biological research station in south-western Togo (now Adéle) was responsible for much research in this country (Matschie 1893, Amori *et al.* 2016), thus over-pushing citations for a small country as Togo.

Obviously, the overall amount of ornithological studies (at least measured on the basis of the number of peer-reviewed published papers) was also influenced by the relative wealth of the various countries, with the economically stronger countries (for instance, Nigeria, Ivory Coast and Senegal) ranking high and the least developed economies (for instance, Guinea, Liberia, and Mali) lagging behind (OFAC 2012). All of these overall trends have not changed substantially across the years, so, for instance,

the disciplinary sectors that were dominant twenty years ago are still dominant nowadays.

Our review also revealed that there was a clear habitat type effect on the ornithological effort across West Africa, not only (i) in that studies in a given country were clearly linked to the availability of a given target habitat in that country, but also in that (ii) some habitat types were clearly more intensely studied than others also at the global regional scale. Pattern (i) is clearly explained also by the relative lack of economic resources by local scientific institutions (including the most prestigious universities in, for instance, Nigeria and Ivory Coast), thus preventing local scientific teams to expand their field researches outside the political borders of their own country. Pattern (ii) is explained by the differential focus of international donor organizations on the different habitat types of West Africa. So, for instance, the dominance of rainforest studies in West African ornithology (*e.g.* Gartshore 1995, Forbeseh & Ikfuingei 2007) is almost certainly linked to the fact that rainforests receive more funds for ecological and conservation studies than any other terrestrial habitat type in the region, thus pushing also the local scientific teams to concentrate on rainforest research projects (but see also, for instance Mullié *et al.* 1999, Moreno-Opo *et al.* 2013).

A particularly crucial issue for the next decade of West African ornithology would be the intensification of the studies on migratory species. Many long-distance Palearctic migrants spend the winter in Sub-Saharan Africa, in a large area extending over 20 million km<sup>2</sup> and comprising many different habitats, from Sudan steppe to the wet forests of Western Africa (Hake *et al.* 2003, Newton 2008). This long-distance migration systems could be an important focus for national and international conservation policy (Convention on Migratory Species, available at <http://www.cms.int/>). Furthermore, many of the bird species that migrate between Europe and Africa are in decline throughout their breeding range (Zwarts *et al.* 2009).

Birds that spend the winter in the Sahel use landscapes intensively managed by farmers and livestock keepers (Raynaut 1998). In addition, given that wide regions of West Africa are heavily altered, more bird species occupy man-modified habitats (Raynaut 1998, Herremans & Herremans-Tonnoeyr 2000, Anadón *et al.* 2010, Limiñana *et al.* 2012). Wide evidence suggests that deteriorating conditions on West African wintering grounds influence survival and population size of Palearctic birds (*e.g.* Peach *et al.* 1991, Szép 1995, Eraud *et al.* 2009), including raptors (Clarke 2002, Grande *et al.* 2009, Zwarts *et al.* 2009, Mihoub *et al.* 2010). Thus, the population size effects that Eurasian migratory species should suffer because of the deteriorating ecosystem integrity in West Africa should be deeply analyzed and will require careful attention in the next decade also using quantitative approaches aimed to assess the threat regime in time and space (duration,

intensity, frequency, size, reversibility, etc.; Salafsky *et al.* 2002, 2003, 2008; review in Battisti *et al.* 2016). Moreover, during the yearly migrations, birds have the potential of dispersing microorganisms that can be dangerous for human and animal health (Reed *et al.* 2003, Hubalek 2004). In fact, birds could be responsible for the wide geographic distribution of various pathogens, as viruses (*e.g.* West Nile, Sindbis [SINV], influenza A, Newcastle disease), Bacteria (*e.g.* *Borrelia*, *Mycobacteria*, *Salmonellae*), and Protozoa (*e.g.* *Cryptosporidia*). Enhancing the knowledge about bird movements/migrations between West Africa and Europe may be useful to improve disease surveillance schemes or to even define preventive mitigation strategies (Jourdain *et al.* 2007).

In the last 40 years, the economic development of wide regions of the African continent (including West Africa) has been accomplished with deep modifications in land use and land cover, especially for the cropland expansion (Brink & Eva 2009) and the loss of native habitats has contributed to significant wildlife decline in Africa's savannahs and forests. In addition, protected areas are fragmented, perforated, degraded and hyper-porose at the borders, with a suboptimal safeguarding of the target habitats and species (Thiollay & Clobert 1990; for a synthesis of ecosystem effects: Saunders *et al.* 1991, Lindenmayer & Fisher 2006; for birds, see: Simberloff 1994, Wiens 1994). More species of birds, notably raptors, consequently undergo severe declines (Thiollay 2006a, Thiollay 2006b, Thiollay 2007a, Thiollay 2007b) since large body sized and specialized species are highly sensitive to habitat fragmentation (and to its spatial and functional components: reduction in fragment size, increase in isolation, degradation due to matrix-edge effect; Henle *et al.* 2004; Ewers & Didham 2006; examples for other groups: Amici & Battisti 2009, Battisti and Luiselli 2010).

In particular, West African vulture populations have been declining throughout the last 30 years, with a population loss of about 95 % being estimated (Rondeau & Thiollay 2004, Thiollay 2006a, Thiollay 2006b, Thiollay 2007a, Thiollay 2007b) caused by poisoning (Bridgeford 2001, Mijeje 2009, Ogada *et al.* 2016), bioaccumulation (Jenkins 1980, Locke & Thomas 1996, Miller *et al.* 2002) and use for traditional medicine (McKean 2004, Verdoorn *et al.* 2004, Mander *et al.* 2007, Buij *et al.* 2015). It is therefore necessary to implement studies in West Africa aimed at preserving the habitats used by both Afro-tropical species and Euro-Asian migrants to develop (i) standardized conservation strategies and tactics at different spatial and temporal scales (Margoluis & Salafsky 1998) and (ii) a more effective network planning of protected areas, functionally designed for the species-specific sensitive targets (Bennett 1999, Battisti 2003).

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Supplementary material S1. - Summary of the Google Scholar search using habitat + region + disciplinary sector as 'key words'. For more details, see the text.

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Rainforest	Guinea Conakry	Bird Community Ecology	225	152
Rainforest	Guinea Conakry	Bird Taxonomy	204	152
Rainforest	Guinea Conakry	Bird Population Biology	206	144
Rainforest	Guinea Conakry	Bird Conservation Biology	173	112
Rainforest	Guinea Conakry	Pollution Effects On Birds	113	70
Rainforest	Guinea Conakry	Climate Change Effects On Birds	253	177
Rainforest	Sierra Leone	Bird Community Ecology	2880	1690
Rainforest	Sierra Leone	Bird Taxonomy	2710	1510
Rainforest	Sierra Leone	Bird Population Biology	2950	1680
Rainforest	Sierra Leone	Bird Conservation Biology	2390	1430
Rainforest	Sierra Leone	Pollution Effects On Birds	1990	1220
Rainforest	Sierra Leone	Climate Change Effects On Birds	4790	2940
Rainforest	Liberia	Bird Community Ecology	2150	1370
Rainforest	Liberia	Bird Taxonomy	1360	854
Rainforest	Liberia	Bird Population Biology	2890	1660
Rainforest	Liberia	Bird Conservation Biology	2390	1430
Rainforest	Liberia	Pollution Effects On Birds	1330	837
Rainforest	Liberia	Climate Change Effects On Birds	2940	1750
Rainforest	Ivory Coast	Bird Community Ecology	7410	4360
Rainforest	Ivory Coast	Bird Taxonomy	6710	3890
Rainforest	Ivory Coast	Bird Population Biology	7720	4510
Rainforest	Ivory Coast	Bird Conservation Biology	6360	3830
Rainforest	Ivory Coast	Pollution Effects On Birds	3550	2100
Rainforest	Ivory Coast	Climate Change Effects On Birds	7600	4540
Rainforest	Ghana	Bird Community Ecology	5810	3910
Rainforest	Ghana	Bird Taxonomy	3200	2080
Rainforest	Ghana	Bird Population Biology	7510	4680
Rainforest	Ghana	Bird Conservation Biology	6470	4180
Rainforest	Ghana	Pollution Effects On Birds	3420	2220
Rainforest	Ghana	Climate Change Effects On Birds	7690	5010
Rainforest	Togo	Bird Community Ecology	1440	942
Rainforest	Togo	Bird Taxonomy	919	608
Rainforest	Togo	Bird Population Biology	17000	14700
Rainforest	Togo	Bird Conservation Biology	16400	11900
Rainforest	Togo	Pollution Effects On Birds	14600	9150
Rainforest	Togo	Climate Change Effects On Birds	2250	1450
Rainforest	Benin	Bird Community Ecology	1950	1320
Rainforest	Benin	Bird Taxonomy	1160	812
Rainforest	Benin	Bird Population Biology	3010	2000
Rainforest	Benin	Bird Conservation Biology	2550	1680
Rainforest	Benin	Pollution Effects On Birds	1790	1150
Rainforest	Benin	Climate Change Effects On Birds	3220	2140
Rainforest	Nigeria	Bird Community Ecology	7570	4850
Rainforest	Nigeria	Bird Taxonomy	4230	2610
Rainforest	Nigeria	Bird Population Biology	7980	5130
Rainforest	Nigeria	Bird Conservation Biology	8470	5370
Rainforest	Nigeria	Pollution Effects On Birds	6000	3750
Rainforest	Nigeria	Climate Change Effects On Birds	11200	6980
Rainforest	Niger	Bird Community Ecology	4430	3000
Rainforest	Niger	Bird Taxonomy	2930	1930
Rainforest	Niger	Bird Population Biology	13200	8120
Rainforest	Niger	Bird Conservation Biology	10800	6910
Rainforest	Niger	Pollution Effects On Birds	7360	4640

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Rainforest	Niger	Climate Change Effects On Birds	13400	8440
Rainforest	Burkina Faso	Bird Community Ecology	2170	1480
Rainforest	Burkina Faso	Bird Taxonomy	1780	1180
Rainforest	Burkina Faso	Bird Population Biology	2130	1420
Rainforest	Burkina Faso	Bird Conservation Biology	1880	1270
Rainforest	Burkina Faso	Pollution Effects On Birds	1200	753
Rainforest	Burkina Faso	Climate Change Effects On Birds	2310	1570
Rainforest	Mali	Bird Community Ecology	2860	1780
Rainforest	Mali	Bird Taxonomy	1750	982
Rainforest	Mali	Bird Population Biology	3910	2270
Rainforest	Mali	Bird Conservation Biology	3180	1880
Rainforest	Mali	Pollution Effects On Birds	1980	1160
Rainforest	Mali	Climate Change Effects On Birds	4120	2460
Rainforest	Senegal	Bird Community Ecology	3310	2130
Rainforest	Senegal	Bird Taxonomy	2130	1340
Rainforest	Senegal	Bird Population Biology	4670	2790
Rainforest	Senegal	Bird Conservation Biology	3790	2330
Rainforest	Senegal	Pollution Effects On Birds	2190	1310
Rainforest	Senegal	Climate Change Effects On Birds	4710	2840
Rainforest	Gambia	Bird Community Ecology	1340	869
Rainforest	Gambia	Bird Taxonomy	828	536
Rainforest	Gambia	Bird Population Biology	1920	1150
Rainforest	Gambia	Bird Conservation Biology	1560	951
Rainforest	Gambia	Pollution Effects On Birds	1860	1130
Rainforest	Gambia	Climate Change Effects On Birds	1980	1210
Guinea Savannah	Guinea Conakry	Bird Community Ecology	279	155
Guinea Savannah	Guinea Conakry	Bird Taxonomy	252	138
Guinea Savannah	Guinea Conakry	Bird Population Biology	240	136
Guinea Savannah	Guinea Conakry	Bird Conservation Biology	198	109
Guinea Savannah	Guinea Conakry	Pollution Effects On Birds	127	71
Guinea Savannah	Guinea Conakry	Climate Change Effects On Birds	305	165
Guinea Savannah	Sierra Leone	Bird Community Ecology	1880	1060
Guinea Savannah	Sierra Leone	Bird Taxonomy	2070	1060
Guinea Savannah	Sierra Leone	Bird Population Biology	1270	721
Guinea Savannah	Sierra Leone	Bird Conservation Biology	1400	828
Guinea Savannah	Sierra Leone	Pollution Effects On Birds	902	503
Guinea Savannah	Sierra Leone	Climate Change Effects On Birds	2400	1270
Guinea Savannah	Liberia	Bird Community Ecology	1660	899
Guinea Savannah	Liberia	Bird Taxonomy	1910	963
Guinea Savannah	Liberia	Bird Population Biology	1780	962
Guinea Savannah	Liberia	Bird Conservation Biology	1320	759
Guinea Savannah	Liberia	Pollution Effects On Birds	713	405
Guinea Savannah	Liberia	Climate Change Effects On Birds	1840	962
Guinea Savannah	Ivory Coast	Bird Community Ecology	3550	2060
Guinea Savannah	Ivory Coast	Bird Taxonomy	3660	2030
Guinea Savannah	Ivory Coast	Bird Population Biology	3710	2160
Guinea Savannah	Ivory Coast	Bird Conservation Biology	2760	1640
Guinea Savannah	Ivory Coast	Pollution Effects On Birds	1440	864
Guinea Savannah	Ivory Coast	Climate Change Effects On Birds	3900	2170
Guinea Savannah	Ghana	Bird Community Ecology	3780	2310
Guinea Savannah	Ghana	Bird Taxonomy	3660	2130
Guinea Savannah	Ghana	Bird Population Biology	3870	2330
Guinea Savannah	Ghana	Bird Conservation Biology	2890	1810
Guinea Savannah	Ghana	Pollution Effects On Birds	1600	1010
Guinea Savannah	Ghana	Climate Change Effects On Birds	3960	2430

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Guinea Savannah	Togo	Bird Community Ecology	4550	2670
Guinea Savannah	Togo	Bird Taxonomy	4590	2490
Guinea Savannah	Togo	Bird Population Biology	4940	2860
Guinea Savannah	Togo	Bird Conservation Biology	3380	2030
Guinea Savannah	Togo	Pollution Effects On Birds	2300	1380
Guinea Savannah	Togo	Climate Change Effects On Birds	1640	1020
Guinea Savannah	Benin	Bird Community Ecology	1910	1230
Guinea Savannah	Benin	Bird Taxonomy	1880	1170
Guinea Savannah	Benin	Bird Population Biology	1960	1270
Guinea Savannah	Benin	Bird Conservation Biology	1450	950
Guinea Savannah	Benin	Pollution Effects On Birds	891	552
Guinea Savannah	Benin	Climate Change Effects On Birds	2160	1360
Guinea Savannah	Nigeria	Bird Community Ecology	4960	2860
Guinea Savannah	Nigeria	Bird Taxonomy	5040	2770
Guinea Savannah	Nigeria	Bird Population Biology	5410	3140
Guinea Savannah	Nigeria	Bird Conservation Biology	3670	2300
Guinea Savannah	Nigeria	Pollution Effects On Birds	2290	1310
Guinea Savannah	Nigeria	Climate Change Effects On Birds	5410	3170
Guinea Savannah	Niger	Bird Community Ecology	5630	3260
Guinea Savannah	Niger	Bird Taxonomy	5880	3190
Guinea Savannah	Niger	Bird Population Biology	6150	3560
Guinea Savannah	Niger	Bird Conservation Biology	4220	2630
Guinea Savannah	Niger	Pollution Effects On Birds	2840	1660
Guinea Savannah	Niger	Climate Change Effects On Birds	6220	3600
Guinea Savannah	Burkina Faso	Bird Community Ecology	1720	1140
Guinea Savannah	Burkina Faso	Bird Taxonomy	1590	1030
Guinea Savannah	Burkina Faso	Bird Population Biology	1720	1130
Guinea Savannah	Burkina Faso	Bird Conservation Biology	1300	845
Guinea Savannah	Burkina Faso	Pollution Effects On Birds	790	485
Guinea Savannah	Burkina Faso	Climate Change Effects On Birds	1820	1210
Guinea Savannah	Mali	Bird Community Ecology	2100	1240
Guinea Savannah	Mali	Bird Taxonomy	2330	1310
Guinea Savannah	Mali	Bird Population Biology	1320	803
Guinea Savannah	Mali	Bird Conservation Biology	1480	894
Guinea Savannah	Mali	Pollution Effects On Birds	864	501
Guinea Savannah	Mali	Climate Change Effects On Birds	2170	1320
Guinea Savannah	Senegal	Bird Community Ecology	3090	1770
Guinea Savannah	Senegal	Bird Taxonomy	3320	1780
Guinea Savannah	Senegal	Bird Population Biology	3340	1920
Guinea Savannah	Senegal	Bird Conservation Biology	2390	1430
Guinea Savannah	Senegal	Pollution Effects On Birds	1270	725
Guinea Savannah	Senegal	Climate Change Effects On Birds	3310	1850
Guinea Savannah	Gambia	Bird Community Ecology	1490	851
Guinea Savannah	Gambia	Bird Taxonomy	1530	822
Guinea Savannah	Gambia	Bird Population Biology	1610	935
Guinea Savannah	Gambia	Bird Conservation Biology	1100	664
Guinea Savannah	Gambia	Pollution Effects On Birds	1730	948
Guinea Savannah	Gambia	Climate Change Effects On Birds	1830	1030
Mangrove	Guinea Conakry	Bird Community Ecology	194	124
Mangrove	Guinea Conakry	Bird Taxonomy	138	87
Mangrove	Guinea Conakry	Bird Population Biology	164	108
Mangrove	Guinea Conakry	Bird Conservation Biology	152	96
Mangrove	Guinea Conakry	Pollution Effects On Birds	117	71
Mangrove	Guinea Conakry	Climate Change Effects On Birds	205	125
Mangrove	Sierra Leone	Bird Community Ecology	1530	948

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Mangrove	Sierra Leone	Bird Taxonomy	1490	801
Mangrove	Sierra Leone	Bird Population Biology	1510	911
Mangrove	Sierra Leone	Bird Conservation Biology	1260	817
Mangrove	Sierra Leone	Pollution Effects On Birds	1400	855
Mangrove	Sierra Leone	Climate Change Effects On Birds	2860	1580
Mangrove	Liberia	Bird Community Ecology	1230	725
Mangrove	Liberia	Bird Taxonomy	1110	575
Mangrove	Liberia	Bird Population Biology	1210	687
Mangrove	Liberia	Bird Conservation Biology	995	611
Mangrove	Liberia	Pollution Effects On Birds	850	525
Mangrove	Liberia	Climate Change Effects On Birds	1560	825
Mangrove	Ivory Coast	Bird Community Ecology	3230	1900
Mangrove	Ivory Coast	Bird Taxonomy	3140	1650
Mangrove	Ivory Coast	Bird Population Biology	3330	1940
Mangrove	Ivory Coast	Bird Conservation Biology	2770	1670
Mangrove	Ivory Coast	Pollution Effects On Birds	2220	1290
Mangrove	Ivory Coast	Climate Change Effects On Birds	4160	2150
Mangrove	Ghana	Bird Community Ecology	3340	2200
Mangrove	Ghana	Bird Taxonomy	2570	1620
Mangrove	Ghana	Bird Population Biology	3340	2170
Mangrove	Ghana	Bird Conservation Biology	2850	1910
Mangrove	Ghana	Pollution Effects On Birds	2300	1530
Mangrove	Ghana	Climate Change Effects On Birds	3650	2400
Mangrove	Togo	Bird Community Ecology	9940	6310
Mangrove	Togo	Bird Taxonomy	846	507
Mangrove	Togo	Bird Population Biology	2130	1370
Mangrove	Togo	Bird Conservation Biology	8580	5470
Mangrove	Togo	Pollution Effects On Birds	7290	4530
Mangrove	Togo	Climate Change Effects On Birds	1200	772
Mangrove	Benin	Bird Community Ecology	1440	950
Mangrove	Benin	Bird Taxonomy	1140	694
Mangrove	Benin	Bird Population Biology	1360	907
Mangrove	Benin	Bird Conservation Biology	1140	753
Mangrove	Benin	Pollution Effects On Birds	1100	726
Mangrove	Benin	Climate Change Effects On Birds	1730	1090
Mangrove	Nigeria	Bird Community Ecology	5180	3220
Mangrove	Nigeria	Bird Taxonomy	2480	1350
Mangrove	Nigeria	Bird Population Biology	5090	3150
Mangrove	Nigeria	Bird Conservation Biology	4050	2660
Mangrove	Nigeria	Pollution Effects On Birds	3810	2450
Mangrove	Nigeria	Climate Change Effects On Birds	5610	3520
Mangrove	Niger	Bird Community Ecology	6960	4320
Mangrove	Niger	Bird Taxonomy	3640	2070
Mangrove	Niger	Bird Population Biology	7030	4310
Mangrove	Niger	Bird Conservation Biology	5720	3710
Mangrove	Niger	Pollution Effects On Birds	5290	3390
Mangrove	Niger	Climate Change Effects On Birds	7580	4620
Mangrove	Burkina Faso	Bird Community Ecology	1010	716
Mangrove	Burkina Faso	Bird Taxonomy	771	543
Mangrove	Burkina Faso	Bird Population Biology	987	707
Mangrove	Burkina Faso	Bird Conservation Biology	879	618
Mangrove	Burkina Faso	Pollution Effects On Birds	744	509
Mangrove	Burkina Faso	Climate Change Effects On Birds	1100	790
Mangrove	Mali	Bird Community Ecology	1680	1110
Mangrove	Mali	Bird Taxonomy	1420	842

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Mangrove	Mali	Bird Population Biology	1680	1090
Mangrove	Mali	Bird Conservation Biology	1380	905
Mangrove	Mali	Pollution Effects On Birds	1160	781
Mangrove	Mali	Climate Change Effects On Birds	1960	1240
Mangrove	Senegal	Bird Community Ecology	3010	1850
Mangrove	Senegal	Bird Taxonomy	2980	1690
Mangrove	Senegal	Bird Population Biology	3290	2070
Mangrove	Senegal	Bird Conservation Biology	2770	1800
Mangrove	Senegal	Pollution Effects On Birds	2020	1250
Mangrove	Senegal	Climate Change Effects On Birds	3680	2220
Mangrove	Gambia	Bird Community Ecology	1250	756
Mangrove	Gambia	Bird Taxonomy	1080	555
Mangrove	Gambia	Bird Population Biology	1250	745
Mangrove	Gambia	Bird Conservation Biology	1010	627
Mangrove	Gambia	Pollution Effects On Birds	1530	865
Mangrove	Gambia	Climate Change Effects On Birds	1580	866
Sahel	Guinea Conakry	Bird Community Ecology	218	126
Sahel	Guinea Conakry	Bird Taxonomy	182	100
Sahel	Guinea Conakry	Bird Population Biology	181	110
Sahel	Guinea Conakry	Bird Conservation Biology	153	87
Sahel	Guinea Conakry	Pollution Effects On Birds	129	73
Sahel	Guinea Conakry	Climate Change Effects On Birds	258	148
Sahel	Sierra Leone	Bird Community Ecology	1170	637
Sahel	Sierra Leone	Bird Taxonomy	1260	671
Sahel	Sierra Leone	Bird Population Biology	594	309
Sahel	Sierra Leone	Bird Conservation Biology	800	410
Sahel	Sierra Leone	Pollution Effects On Birds	650	359
Sahel	Sierra Leone	Climate Change Effects On Birds	1720	957
Sahel	Liberia	Bird Community Ecology	1120	603
Sahel	Liberia	Bird Taxonomy	1070	553
Sahel	Liberia	Bird Population Biology	1080	565
Sahel	Liberia	Bird Conservation Biology	806	444
Sahel	Liberia	Pollution Effects On Birds	632	340
Sahel	Liberia	Climate Change Effects On Birds	1340	736
Sahel	Ivory Coast	Bird Community Ecology	2450	1430
Sahel	Ivory Coast	Bird Taxonomy	2250	1310
Sahel	Ivory Coast	Bird Population Biology	2380	1400
Sahel	Ivory Coast	Bird Conservation Biology	1780	1070
Sahel	Ivory Coast	Pollution Effects On Birds	1380	794
Sahel	Ivory Coast	Climate Change Effects On Birds	2930	1720
Sahel	Ghana	Bird Community Ecology	3290	2030
Sahel	Ghana	Bird Taxonomy	2730	1640
Sahel	Ghana	Bird Population Biology	3080	1850
Sahel	Ghana	Bird Conservation Biology	2350	1450
Sahel	Ghana	Pollution Effects On Birds	1770	1100
Sahel	Ghana	Climate Change Effects On Birds	3770	2360
Sahel	Togo	Bird Community Ecology	3630	2180
Sahel	Togo	Bird Taxonomy	2870	1700
Sahel	Togo	Bird Population Biology	3520	2100
Sahel	Togo	Bird Conservation Biology	2590	1580
Sahel	Togo	Pollution Effects On Birds	2300	1350
Sahel	Togo	Climate Change Effects On Birds	1490	876
Sahel	Benin	Bird Community Ecology	1790	1130
Sahel	Benin	Bird Taxonomy	1560	960
Sahel	Benin	Bird Population Biology	1770	1110

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Sahel	Benin	Bird Conservation Biology	1330	829
Sahel	Benin	Pollution Effects On Birds	956	568
Sahel	Benin	Climate Change Effects On Birds	2120	1360
Sahel	Nigeria	Bird Community Ecology	4590	2700
Sahel	Nigeria	Bird Taxonomy	3740	2130
Sahel	Nigeria	Bird Population Biology	4620	2700
Sahel	Nigeria	Bird Conservation Biology	3440	2050
Sahel	Nigeria	Pollution Effects On Birds	2510	1470
Sahel	Nigeria	Climate Change Effects On Birds	5280	3190
Sahel	Niger	Bird Community Ecology	4180	2500
Sahel	Niger	Bird Taxonomy	3600	2100
Sahel	Niger	Bird Population Biology	4130	2450
Sahel	Niger	Bird Conservation Biology	3090	1880
Sahel	Niger	Pollution Effects On Birds	2430	1460
Sahel	Niger	Climate Change Effects On Birds	4870	2960
Sahel	Burkina Faso	Bird Community Ecology	2270	1520
Sahel	Burkina Faso	Bird Taxonomy	2220	1460
Sahel	Burkina Faso	Bird Population Biology	1210	794
Sahel	Burkina Faso	Bird Conservation Biology	1680	1120
Sahel	Burkina Faso	Pollution Effects On Birds	1390	879
Sahel	Burkina Faso	Climate Change Effects On Birds	3120	2120
Sahel	Mali	Bird Community Ecology	3000	1820
Sahel	Mali	Bird Taxonomy	3030	1790
Sahel	Mali	Bird Population Biology	1650	1010
Sahel	Mali	Bird Conservation Biology	2080	1300
Sahel	Mali	Pollution Effects On Birds	1460	884
Sahel	Mali	Climate Change Effects On Birds	3260	2070
Sahel	Senegal	Bird Community Ecology	3000	1820
Sahel	Senegal	Bird Taxonomy	3030	1790
Sahel	Senegal	Bird Population Biology	1650	1010
Sahel	Senegal	Bird Conservation Biology	2080	1300
Sahel	Senegal	Pollution Effects On Birds	1460	884
Sahel	Senegal	Climate Change Effects On Birds	3260	2070
Sahel	Gambia	Bird Community Ecology	1520	841
Sahel	Gambia	Bird Taxonomy	1330	710
Sahel	Gambia	Bird Population Biology	1520	848
Sahel	Gambia	Bird Conservation Biology	1100	631
Sahel	Gambia	Pollution Effects On Birds	1850	1040
Sahel	Gambia	Climate Change Effects On Birds	1840	1060
Sudanese Savannah	Guinea Conakry	Bird Community Ecology	149	78
Sudanese Savannah	Guinea Conakry	Bird Taxonomy	148	76
Sudanese Savannah	Guinea Conakry	Bird Population Biology	130	70
Sudanese Savannah	Guinea Conakry	Bird Conservation Biology	110	54
Sudanese Savannah	Guinea Conakry	Pollution Effects On Birds	79	38
Sudanese Savannah	Guinea Conakry	Climate Change Effects On Birds	180	93
Sudanese Savannah	Sierra Leone	Bird Community Ecology	1230	628
Sudanese Savannah	Sierra Leone	Bird Taxonomy	1420	672
Sudanese Savannah	Sierra Leone	Bird Population Biology	830	429
Sudanese Savannah	Sierra Leone	Bird Conservation Biology	896	475
Sudanese Savannah	Sierra Leone	Pollution Effects On Birds	620	324
Sudanese Savannah	Sierra Leone	Climate Change Effects On Birds	1480	752
Sudanese Savannah	Liberia	Bird Community Ecology	1080	561
Sudanese Savannah	Liberia	Bird Taxonomy	1250	612
Sudanese Savannah	Liberia	Bird Population Biology	1150	571
Sudanese Savannah	Liberia	Bird Conservation Biology	814	435

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Sudanese Savannah	Liberia	Pollution Effects On Birds	525	279
Sudanese Savannah	Liberia	Climate Change Effects On Birds	1220	632
Sudanese Savannah	Ivory Coast	Bird Community Ecology	2190	1200
Sudanese Savannah	Ivory Coast	Bird Taxonomy	2290	1220
Sudanese Savannah	Ivory Coast	Bird Population Biology	2270	1250
Sudanese Savannah	Ivory Coast	Bird Conservation Biology	1620	904
Sudanese Savannah	Ivory Coast	Pollution Effects On Birds	911	526
Sudanese Savannah	Ivory Coast	Climate Change Effects On Birds	2540	1400
Sudanese Savannah	Ghana	Bird Community Ecology	2190	1200
Sudanese Savannah	Ghana	Bird Taxonomy	2290	1220
Sudanese Savannah	Ghana	Bird Population Biology	2270	1250
Sudanese Savannah	Ghana	Bird Conservation Biology	1620	904
Sudanese Savannah	Ghana	Pollution Effects On Birds	911	526
Sudanese Savannah	Ghana	Climate Change Effects On Birds	2540	1400
Sudanese Savannah	Togo	Bird Community Ecology	2560	1480
Sudanese Savannah	Togo	Bird Taxonomy	2440	1330
Sudanese Savannah	Togo	Bird Population Biology	2670	1510
Sudanese Savannah	Togo	Bird Conservation Biology	1870	1070
Sudanese Savannah	Togo	Pollution Effects On Birds	1340	794
Sudanese Savannah	Togo	Climate Change Effects On Birds	1200	688
Sudanese Savannah	Benin	Bird Community Ecology	1390	848
Sudanese Savannah	Benin	Bird Taxonomy	1390	831
Sudanese Savannah	Benin	Bird Population Biology	1440	879
Sudanese Savannah	Benin	Bird Conservation Biology	1060	651
Sudanese Savannah	Benin	Pollution Effects On Birds	646	372
Sudanese Savannah	Benin	Climate Change Effects On Birds	1580	960
Sudanese Savannah	Nigeria	Bird Community Ecology	3590	1980
Sudanese Savannah	Nigeria	Bird Taxonomy	3710	1930
Sudanese Savannah	Nigeria	Bird Population Biology	3830	2070
Sudanese Savannah	Nigeria	Bird Conservation Biology	2490	1490
Sudanese Savannah	Nigeria	Pollution Effects On Birds	1700	889
Sudanese Savannah	Nigeria	Climate Change Effects On Birds	4050	2250
Sudanese Savannah	Niger	Bird Community Ecology	4060	2270
Sudanese Savannah	Niger	Bird Taxonomy	4210	2210
Sudanese Savannah	Niger	Bird Population Biology	4290	2360
Sudanese Savannah	Niger	Bird Conservation Biology	2840	1720
Sudanese Savannah	Niger	Pollution Effects On Birds	2100	1140
Sudanese Savannah	Niger	Climate Change Effects On Birds	4610	2580
Sudanese Savannah	Burkina Faso	Bird Community Ecology	1520	1000
Sudanese Savannah	Burkina Faso	Bird Taxonomy	1440	919
Sudanese Savannah	Burkina Faso	Bird Population Biology	1540	989
Sudanese Savannah	Burkina Faso	Bird Conservation Biology	1180	763
Sudanese Savannah	Burkina Faso	Pollution Effects On Birds	693	426
Sudanese Savannah	Burkina Faso	Climate Change Effects On Birds	1630	1070
Sudanese Savannah	Mali	Bird Community Ecology	1980	1150
Sudanese Savannah	Mali	Bird Taxonomy	2040	1150
Sudanese Savannah	Mali	Bird Population Biology	1280	782
Sudanese Savannah	Mali	Bird Conservation Biology	1400	833
Sudanese Savannah	Mali	Pollution Effects On Birds	809	471
Sudanese Savannah	Mali	Climate Change Effects On Birds	2080	1230
Sudanese Savannah	Senegal	Bird Community Ecology	2610	1470
Sudanese Savannah	Senegal	Bird Taxonomy	2800	1490
Sudanese Savannah	Senegal	Bird Population Biology	2760	1550
Sudanese Savannah	Senegal	Bird Conservation Biology	1990	1170
Sudanese Savannah	Senegal	Pollution Effects On Birds	1090	619

Habitats	Country	Disciplinary Sectors	No. of Results	No. Results in 2006-2017
Sudanese Savannah	Senegal	Climate Change Effects On Birds	2870	1600
Sudanese Savannah	Gambia	Bird Community Ecology	1150	632
Sudanese Savannah	Gambia	Bird Taxonomy	1230	642
Sudanese Savannah	Gambia	Bird Population Biology	1250	692
Sudanese Savannah	Gambia	Bird Conservation Biology	831	475
Sudanese Savannah	Gambia	Pollution Effects On Birds	1310	698
Sudanese Savannah	Gambia	Climate Change Effects On Birds	1400	768