

The Orange River avifauna: abundance, richness and comparisons

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Like many other southern African rivers, the avifaunal richness and abundance of the Orange River, southern Africa's longest, remains virtually unknown. Given that the Orange River runs through hyper-arid regions in its lower reaches, its linear oasis effect and its role as a reservoir for Red Data bird species is likely but has not been quantified. Two surveys either side of the border town of Noordoewer, in the rainy and dry seasons of 1996 and 1997 determined that species richness was higher in riverine habitat (71 species) than in the surrounding Nama Karoo (46 species) confirming the linear oasis effect. Surveys revealed five Namibian Red Data species. Peregrine Falcons, *Falco peregrinus*, and African Fish Eagles, *Haliaeetus vocifer*, were relatively common while the endangered Cape Eagle Owl, *Bubo capensis*, occurred sporadically. Among wetland Red Data bird species, Black Storks, *Ciconia nigra*, occurred in less disturbed areas, and White-backed Night Herons, *Gorsachius leuconotus*, were an unexpected species at this locality. The overall species richness of 103 birds and a density of riparian birds of 31–34 birds/10 km, makes the lower Orange River avifauna similar to the Cunene River but tenfold less abundant than Namibia's other perennial rivers. Despite the low diversity, the arid habitats of the lower Orange River support greater diversity than more easterly regions when all current surveys of richness and abundance from Lesotho to the mouth on the Namib coast are combined. This east–west trend may be explained by the slower flow and warmer water of the lower Orange River but natural turbidity and regulation may explain the generally low diversity and abundance indices. Major rivers in southern Africa appear to have been overlooked as wetland habitats, and further avifaunal surveys of all of them are to be recommended.

INTRODUCTION

Despite the scarcity of perennial rivers in arid landscapes and their potential importance as linear hotspots of diversity in desert environments, rivers in southern Africa are among the most poorly studied avian habitats. The lower Orange River is one such habitat, and runs for c. 600 km from Augrabies Falls in the east to Alexander Bay and Oranjemund in the west. Only one quantitative study of the lower Orange River's avifauna (Allan & Jenkins 1993) has been published and only species lists (Winterbottom 1972) or relative abundance estimates are available for other sections of the river (Harrison *et al.* 1997). By contrast the mouth is relatively well known and supports large numbers of birds (Ryan & Cooper 1985; Williams 1986; Anderson, in prep.). A paucity of information is also true of similar arid-zone rivers both north (e.g. Braine 1990; Simmons *et al.* 1993), and south of the Orange River, where invertebrates, fish and riparian plants are well known in South African rivers but birds and mammals are virtually unstudied (e.g. O'Keefe 1986; Davies *et al.* 1993). The recent compilation of wetland bird data

including some from South African flood plains (Taylor 1997; Taylor *et al.* 1999), highland rivers (Allan 1999; Allan & Davies 1999) and northern rivers in Botswana (Herremans 1999) is beginning to redress this imbalance. There remains, however, a major gap in our understanding of the avifaunal importance of these rivers, given the high species richness of birds associated with more tropical rivers in Namibia (Robertson *et al.* 1998). This gap in avifaunal knowledge is also surprising given the attention most rivers have received from aquatic biologists in South Africa and Namibia (e.g. Whitfield & Bruton 1989; Allanson *et al.* 1990; Bethune 1991; Van Zyl 1993; Hay *et al.* 1997).

The supposition that such rivers, particularly those in the arid regions, act as linear oases, and increase species diversity over surrounding areas (Clancey 1994) has recently been illustrated by distribution maps in Harrison *et al.* (1997). For example species distributions of the African Fish Eagle, *Haliaeetus vocifer*, and the Cape Robin, *Cossypha caffra*, delineate the course of the river exactly through otherwise uninhabited terrain. Given that the lower Orange River may enhance species richness, it may also harbour Namibian Red Data species (Brown *et al.* 1997) along its banks or in the rocky gorges through which it flows. However, the population status of the riparian species, the Red Data birds, or raptors inhabiting the rocky gorges cannot be gauged without estimating density and local abundance. That it is one of southern Africa's longest and most regulated rivers (Cambray 1984; Davies *et al.* 1993), adds particular urgency to studies of its biotic diversity.

The aims of this paper are to: i) compare species richness indices of birds (and restricted range species) found in the lower Orange River with those habitats immediately adjacent to it, to determine if the river functions as a linear oasis; ii) report linear densities of wetland and riverine species, to estimate total populations along the river, iii) report on Red Data species which the Southern African Bird Atlas (Harrison *et al.* 1997) appears to have under-sampled; iv) look for trends across the 1800 km from the upper Orange River in Lesotho to its mouth in the west, and v) compare our findings with unpublished data for other perennial Namibian rivers.

Study areas

At 1950 km the Orange River is southern Africa's longest, rising in the mountains of Lesotho and draining almost 50 % of South Africa's land area before emptying in to the Atlantic Ocean at the Oranjemund (van Zyl 1991). The lower Orange River cuts east–west across the Nama Karoo biome that extends north–south from western South Africa through Namibia. The 50 km of river near Noordoewer (28° 43'S, 17° 28'E; Fig. 1) lies just outside the winter-rainfall zone, where rainfall averages about 50 mm per year (van der Merwe 1983). Vegetation on both sides of the river was originally categorized as Orange River Brokenveld (Acocks 1975) which later bisects Namaqualand Brokenveld.

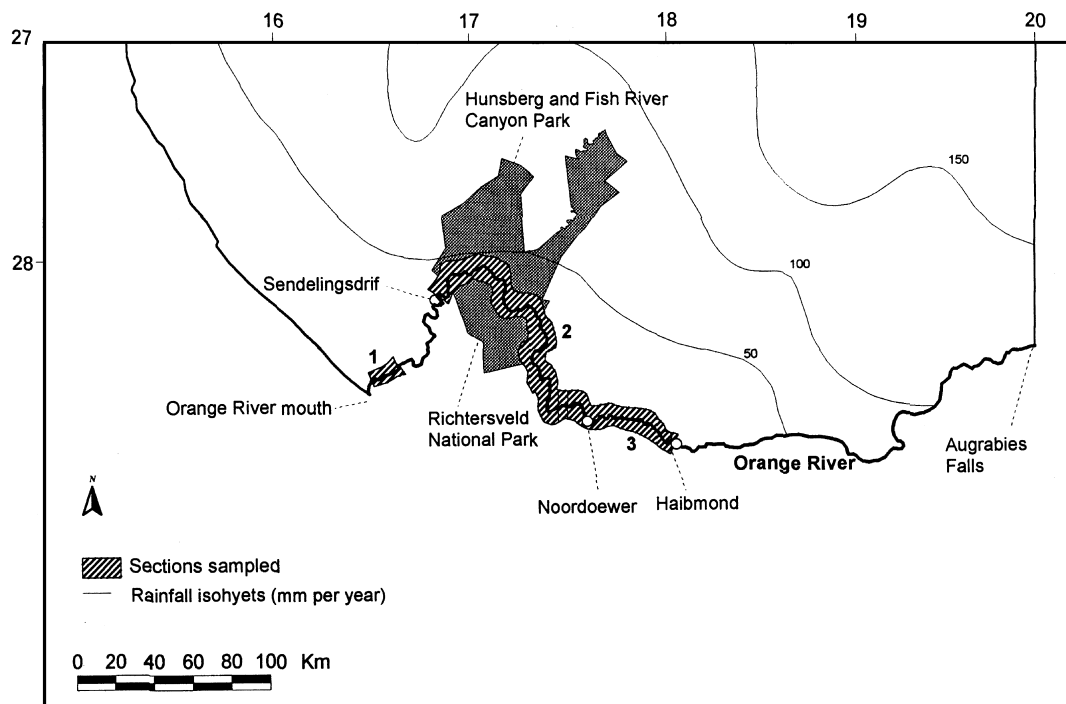


FIG. 1. The lower Orange River and the Noordoewer-centred study site. River transects where surveys mentioned in the text occurred are shown. They are: 1: Bridge to Skilpadkop, 22.5 km (10 km from the mouth; Anderson & Kolberg, unpubl.); 2: Allan & Jenkins 1993 study, 160 km from Kotzeshoop to Sendelingsdrif; 3: this study, 50 km from Haibmond to 16 km past Noordoewer. Sections 2 and 3 overlap by approximately 10 km.

However, the environs were re-classified in 1996 into the following categories: from Augrabies Falls to Noordoewer as Orange River Nama Karoo, from Noordoewer west to the western Richtersveld as upland Succulent Karoo, and finally the western Richtersveld to Oranjemund as lowland Succulent Karoo (Low & Robelo 1996). This new categorization reflects the influence of the highland Richtersveld on the surrounding habitat and at under 100 mm of rainfall the whole study area falls within arid desert environment. Where the river broadens, intensive farming of lucerne and grapes occurs, but most areas, particularly downstream, are bounded by high cliffs and arid mountains and remain relatively pristine.

The local catchment of the Orange River around Noordoewer supports many small woody shrubs, but succulent plants usually dominate the open landscape, with isolated *Aloe dichotoma* the only trees. By contrast, the riparian fringes of the Orange River are completely tree-lined with mainly alien invasives. The avifauna of the area is therefore a mixture of Karoo species with its complement of southern African endemics, cliff-nesting species found in the canyons, and the wetland species of the Orange River. In Lesotho, close to the newly constructed Katse and Mohale Dams, the river runs from the alpine highlands through to lowland areas in the grassland biome of South Africa. Livestock grazing and small-scale subsistence agriculture are the dominant land-use patterns (Allan 1999).

METHODS

R.E.S. undertook sampling of the middle section of the lower Orange River from 15–21 December 1996 to determine bird numbers following good rains in the summer, and from 1–9 April 1997 for birds during a drier period in early winter. Two study periods were chosen because of the expected influence of rains on species richness in the surrounding areas. Many arid birds are nomadic and move into areas of good rains (Maclean 1974; Lloyd 1999). Rains fell in October and November 1996, amounting to about 65 mm. As a result, the area was greener in December 1996

than it has been for about 16 years (G. van Zyl, pers. comm.). The Orange River flow was higher than normal relative to preceding years, and was therefore fast-flowing and turbid during the survey periods. To survey riparian species the river was canoed either side of the border crossing at Noordoewer for 50 km in December 1996, and 10 km in April 1997 (the latter survey was curtailed by loss of the canoe in the strong current). Every bird seen was recorded and linear density estimates derived from the totals divided by the distance canoed. Surveys for birds not visible from the river itself were undertaken on foot in the gorges leading into the Orange River and on the steep and rocky riverine banks themselves. In this way birds not visible from the river were added to the species richness lists. Simultaneous bird surveys in five regions within 15 km of the river (R.E.S., unpubl. data) allowed a comparison of species richness values in stony Nama Karoo habitats away from the river with those along riparian fringes themselves.

D.G.A. surveyed 131 km of Orange River in Lesotho where it is called the Senqu River. The river here is fast-flowing in the highland area at 1500–1800 m a.s.l. some 1800 km from the mouth. A survey was conducted by inflatable canoe in March 1996. The birds recorded are given as birds/10 km of river and compared with all other counts.

Additional published data of wetland birds were available from surveys undertaken by Allan and Jenkins (1993) and ten unpublished African Waterfowl Surveys (e.g. Dodman *et al.* 1998) undertaken in the lower reaches of the Orange River (within 10 km of but excluding the mouth) by M. Anderson and H. Kolberg since 1997. Comparisons of avian richness and abundance were available from other rivers from monitoring undertaken during African Waterfowl Surveys running since 1990. As national coordinator R.E.S. requested counters on the Cunene, Okavango, Kwando, Zambezi and Chobe rivers to record the number of wetland species over known distances. We were able to compute average linear densities (birds/10 km) for each river and compare them with indices for the Orange River. While best comparisons are made with other desert rivers (e.g.

TABLE 1. Total number of species seen in riverine and Karoo habitats along the Orange River in December 1996 and April 1997. Namibian Red Data birds and Southern African endemics are separated from additional species recorded. B = breeding or nest sites found.

Species	Orange River	Karoo	Species	Orange River	Karoo
Namibian Red Data species			12. White-breasted Cormorant, <i>Phalacrocorax carbo</i>	✓	
1. Black Stork, <i>Ciconia nigra</i>	✓ B		13. Reed Cormorant, <i>Phalacrocorax africanus</i>	✓	
2. White-backed Night Heron, <i>Gorsachius leuconotus</i>	✓		14. Grey Heron, <i>Ardea cinerea</i>	✓	
3. Fish Eagle, <i>Haliaeetus vocifer</i>	✓ B		15. Goliath Heron, <i>Ardea goliath</i>	✓	
4. Peregrine Falcon, <i>Falco peregrinus</i>	✓ B	✓	16. Little Egret, <i>Egretta garzetta</i>	✓	
5. Cape Eagle Owl, * <i>Bubo capensis</i>	✓		17. Cattle Egret, <i>Bubulcus ibis</i>	✓	
Southern African endemics			18. Black-crowned Night Heron, <i>Nycticorax nycticorax</i>	✓	
1. Ludwig's Bustard, <i>Neotis ludwigii</i>		✓	19. Hamerkop, <i>Scopus umbretta</i>	✓	
2. Pale chanting Goshawk, <i>Melierax canorus</i>		✓	20. Black Duck, <i>Anas sparsa</i>	✓	
3. Jackal Buzzard, <i>Buteo rufufuscus</i>		✓	21. Yellow-billed Duck, <i>Anas undulata</i>	✓	
4. Cape Francolin, <i>Francolinus capensis</i>	✓		22. Egyptian Goose, <i>Alopochen aegyptiacus</i>	✓	
5. Burchell's Courser, <i>Cursorius rufus</i>		✓ B	23. Purple Gallinule, <i>Porphyrio porphyrio</i>	✓	
6. Namaqua Sandgrouse, <i>Pterocles namaqua</i>		✓ B	24. Black Crake, <i>Amauornis flavirostris</i>	✓	
7. Bokmakierie, <i>Telophorus zeylonus</i>	✓		25. Three-banded Plover, <i>Charadrius tricollaris</i>	✓	✓
8. Bradfield's Swift, <i>Apus bradfieldi</i>		✓ B	26. Blacksmith Plover, <i>Vanellus armatus</i>	✓	
9. Red-eyed Bulbul, <i>Pycnonotus nigricans</i>	✓		27. Malachite Kingfisher, <i>Alcedo cristata</i>	✓	
10. Grey-backed Finchlark, <i>Eremopterix verticalis</i>		✓	28. Giant Kingfisher, <i>Megaceryle maxima</i>	✓	
11. Black-eared Finchlark, <i>Eremopterix australis</i>		✓	29. Pied Kingfisher, <i>Ceryle rudis</i>	✓	
12. Dusky Sunbird, <i>Nectarinia fusca</i>	✓	✓	30. Pied Crow, <i>Corvus albus</i>		✓
13. Mountain Chat, <i>Oenanthe monticola</i>	✓	✓	31. Rock Pigeon, <i>Columba guinea</i>	✓	
14. Ant-eating Chat, <i>Myrmecocichla formicivora</i>	✓	✓	32. Cape Turtle Dove, <i>Streptopelia capicola</i>	✓	✓
15. Tractrac Chat, <i>Cercomela tractrac</i>	✓	✓	33. Red-eyed Dove, <i>Streptopelia semitorquata</i>	✓	
16. Karoo Long-billed Lark, <i>Certhilauda subcoronata</i>		✓	34. Namaqua Dove, <i>Oena capensis</i>	✓	✓
17. Sabota Lark, <i>Certhilauda sabota</i>		✓	35. Freckled Nightjar, <i>Caprimulgus tristigma</i>	✓	
18. Namaqua Prinia, <i>Phragmacia substriata</i>		✓	36. Cape Wagtail, <i>Motacilla capensis</i>	✓	
19. Grey-backed Cisticola, <i>Cisticola subruficapilla</i>	✓	✓	37. Pied Wagtail, <i>Motacilla aguimp</i>	✓	✓
20. White-backed Mousebird, <i>Colius colius</i>	✓	✓	38. Olive Thrush, <i>Turdus olivaceus</i>	✓	
21. Acacia Pied Barbet, <i>Tricholaema leucomelas</i>	✓	✓	39. Brown-throated Martin, <i>Riparia paludicola</i>	✓	
22. Pale-winged Starling, <i>Onychognathus nabouroup</i>	✓	✓	40. Rock Martin, <i>Hirundo fuligula</i>	✓	✓
23. Cape White-eye, <i>Zosterops pallidus</i>	✓	✓	41. Swallow-tail Bee-eater, <i>Merops hirundineus</i>	✓	✓
24. White-throated, Canary <i>Serinus albogularis</i>	✓	✓	42. Little Swift, <i>Apus melba</i>	✓	
25. Sociable Weaver, <i>Philetairus socius</i>	✓	✓	43. Cape Robin, <i>Cossypha caffra</i>	✓	
26. Cape Sparrow, <i>Passer melanurus</i>	✓	✓	44. Familiar Chat, <i>Cercomela familiaris</i>	✓	✓
27. Black-chested Prinia, <i>Prinia flavicans</i>	✓	✓	45. Red-capped Lark, <i>Calendrella cinerea</i>	✓	✓
28. Pirit Batis, <i>Batis pirit</i>	✓	✓	46. Brubru Shrike, <i>Nilaus afer</i>	✓	
29. Cinnamon-breasted Warbler, <i>Euryptila subcinnamomea</i>		✓	47. Fiscal Shrike, <i>Lanius collaris</i>		✓
30. Cape Bunting, <i>Emberiza capensis</i>	✓	✓	48. Cape Glossy Starling, <i>Lamprotornis nitens</i>	✓	
Additional species (grouped by niche)			49. African Marsh Warbler, <i>Acrocephalus baeticatus</i>	✓	
1. Booted Eagle, <i>Hieraaetus pennatus</i>	✓		50. Cape Reed Warbler, <i>Acrocephalus gracilirostris</i>	✓	
2. Black Eagle, <i>Aquila verreauxii</i>	✓	✓	51. Long-billed Crombec, <i>Sylvietta rufescens</i>		✓
3. Augur Buzzard, <i>Buteo augur</i>	✓		52. Diederik Cuckoo, <i>Chrysococcyx caprius</i>	✓	
4. Steppe Buzzard, <i>Buteo buteo</i>	✓	✓	53. Rock Bunting, <i>Emberiza tahapisi</i>		✓
5. Brown Snake Eagle, <i>Circaetus cinereus</i>	✓		54. Lark-like Bunting, <i>Emberiza impetuani</i>	✓	✓ B
6. Black-breasted Snake Eagle, <i>Circaetus pectoralis</i>	✓		55. Capped Wheatear, <i>Oenanthe pileata</i>		✓
7. Lanner Falcon, <i>Falco biarmicus</i>	✓		56. Fantailed Cisticola, <i>Cisticola juncidis</i>		✓
8. Rock Kestrel, <i>Falco tinnunculus</i>	✓	✓	57. House Sparrow, <i>Passer domesticus</i>	✓	
9. Black-shouldered Kite, <i>Elanus caeruleus</i>	✓		58. Masked Weaver, <i>Ploceus velatus</i>	✓	
10. Spotted Eagle Owl, <i>Bubo africanus</i>	✓		59. Red Bishop, <i>Euplectes orix</i>	✓	
11. Darter, <i>Anhinga melanogaster</i>	✓		60. Common Waxbill, <i>Estrilda astrild</i>	✓	
			Total number of species: 95	71	46

Cunene) there are no published counts available from similar rivers in Angola or South Africa. Wetland birds here refer to those (147 species) defined by Wetlands International (Dodman *et al.* 1998) and exclude martins and swallows. For completeness we have also included kingfishers and wagtails in some analyses. The main wetland groups are: grebes, pelicans, cormorants, herons, storks, ibises, hamerkops, flamingos, cranes, geese and ducks, rallids, gallinules, finfoots, jacanas, waders, gulls, terns, skimmers and wetland raptors.

RESULTS

Species richness and endemics

A total of 95 species of birds was recorded in and adjacent to the lower Orange River during the surveys, of which 30 species (32%) were southern African endemics (Table 1). Lark-like Buntings, *Emberiza impetuani*, were found breeding in December as were several endemics including Namaqua Sandgrouse, *Pterocles namaqua*, Bradfield's Swift, *Apus bradfieldi*, and

TABLE 2. Linear bird (wetland + raptor) densities (birds/km) along the Orange River, 18 and 19 December 1996. Beginning from Haibmond, surveys extended 48 km downstream, 16 km past the South African border bridge. Birds/10 km are compared with Allan & Jenkins' 1993 survey.

Species	Total birds (in 50 km)	Birds/10 km This study versus Allan & Jenkins 1993
White-breasted Cormorant	20	4.0 vs 1.9
Reed Cormorant	10	2.0 vs 0.9
Darter	30	6.0 vs 13.0
Goliath Heron	11	2.2 vs 0.8
Grey Heron	17	3.4 vs 7.3
Little Egret	4	0.8 vs 1.6
White-backed Night Heron	1	0.2 vs 0.0
Black-crowned Night Heron	2	0.4 vs 0.1
Hamerkop	1	0.2 vs 1.1
Black Stork	1(3 nests)	0.2 vs 0.5
Black Duck	7	1.4 vs 2.2
Yellow-billed Duck	5	1.0 vs 0
Egyptian Goose	12	2.4 vs 8.5
Booted Eagle	5	1.0 vs –
Fish Eagle	5	1.0 vs 1.5
Purple Gallinule	3	0.6 vs 0.06
Black Crake	1	0.2 vs 0
Giant Kingfisher	5	1.0 vs 0.7
Pied Kingfisher	14	2.8 vs 0.8
Malachite Kingfisher	5	1.0 vs 0.4
Pied Wagtail	2	0.4 vs 5.8
Total birds (21 species)	160 in 50 km	31.8 vs 55.2
Linear density (birds/km)	3.2	32 vs 55 birds/10 km
Wetland bird density	3.1	31 vs 55 wetland birds/10 km

Burchell's Courser, *Cursorius rufus*. One endemic, the Cape Eagle Owl, *Bubo capensis capensis*, is also on Namibia's Red Data list (Table 1). Namibian Bird Atlas data from the area recorded eight additional species not found during these surveys, of which one (Black-headed Canary, *Serinus alario*) was a southern African endemic. Total species richness list for the environs was thus 103 of which 31 species (30%) were southern African endemics.

Those species associated directly with the river or its fringes and gorges totalled 71, and there were 46 species recorded in the arid surrounds (Table 1). Thus the river harboured 75% of the total 95 species recorded while the Karoo habitat supported 48%.

Linear density and east-west trends

In the first (December) survey of 50 km the average linear

density of wetland birds was 31 birds/10 km. Including Booted Eagles, *Hieraetus pennatus capensis*, that were associated with the river increases the linear density to 32 birds/10 km of river (Table 2). A second 10 km river survey in April 1997 revealed 34 wetland birds per 10 km and revealed only one new species not found in the first survey, the Black-crowned Night Herons *Nycticorax nycticorax*. A short 2-km upstream count from Haibmond exhibited fourfold higher densities (12.5 birds/km) than downstream (2.8 birds/km) despite similar habitat.

Four other surveys and numerous Orange River mouth surveys (captured in the avifauna database for Namibia: Robertson & Jarvis 1999) were combined to determine if any east-west trends in richness or abundance exist for the entire river (Fig. 2). In the upper Orange River in Lesotho, wetland bird densities were low in March 1996 with only 18.7 birds/10 km representing 15 species (Table 3). Further upstream they were lower still (11.2 birds/10 km of 14 species, Allan 1999). Downstream of Haibmond, within 10 km of, but not at the mouth, the river widens, slows and supports many reed and sedge margins; there wetland bird densities were higher, averaging 406 birds/10 km of 26 species ($n = 10$ counts, M. Anderson & H. Kolberg, unpubl. data.). Populations at the mouth have exceeded 15 000 wetland birds of 46 species during the same period (Simmons 1994) and have been even higher in previous years (Grindley 1959; Williams 1986; ORETG 1989). The overall trend, therefore, for the Orange River is for smoothly increasing species richness and abundance values as one travels westwards (Fig. 2).

Red Data species

Five Namibian Red Data birds occurred in the Orange River, with only one being recorded in the surrounding Karoo (Table 1). These included three raptors: the Peregrine Falcon, *Falco peregrinus*, and the Fish Eagle, *Haliaeetus vocifer*, both of which breed along the Orange River. Five pairs of Peregrine Falcons are known to have nest sites on cliffs along 30 km of river from Noordoewer downstream (A. Jenkins, pers. comm.). Two Cape Eagle Owls, were recorded calling in the steepest gorge running into the Orange in April 1997. Their presence both here (M. Griffin, pers. comm.), and further upstream (at Augrabies Falls: A. Jenkins pers. comm.) and downstream (A. Hester, pers. comm.) is confirmed over 10 years.

The least common Red Data species to occur were the Black Stork, *Ciconia nigra*, with three inactive nests high on cliffs along 50 km of river, downstream of Haibmond. A fourth (4-m high) nest, probably of this species, was present about 6 km from the

TABLE 3. Birds recorded from a canoe in 131 km of the Senqu River (upper Orange River) in Lesotho in March 1996.

Species	Number	Linear density (birds/10 km)
White-breasted Cormorant	17	1.3
Grey Heron	4	0.3
Black-headed Heron, <i>Ardea melanocephalus</i>	22	1.7
Hammerkop	5	0.4
Hadedah Ibis, <i>Bostrychia hagedash</i>	10	0.8
Egyptian Goose	9	0.7
South African Shelduck <i>Tadorna cana</i>	4	0.3
Yellow-billed Duck	1	0.08
African Black Duck	54	4.1
Three-banded Plover	3	0.2
Common Sandpiper, <i>Actitis hypoleucos</i>	9	0.7
Greenshank, <i>Tringa nebularia</i>	1	0.08
Giant Kingfisher	3	0.2
African Pied Wagtail	59	4.5
Cape Wagtail	45	3.4
Total: 15 species	246	18.7 birds/10 km

Orange River bird richness and abundance

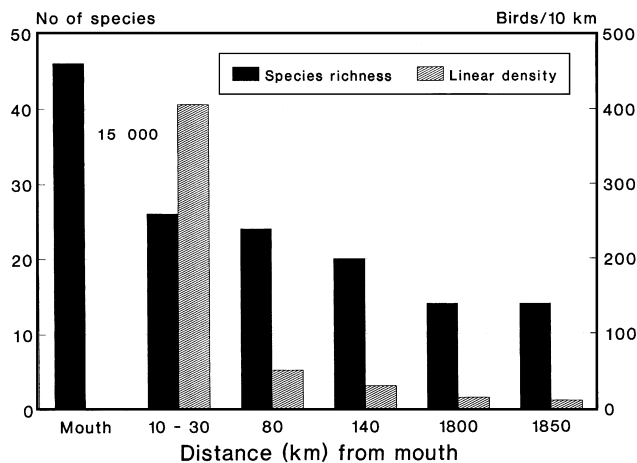


FIG. 2. The decline in avian species richness and linear abundance (wetland birds/10 km) from the Orange River mouth to its mountain source in Lesotho. The study sections were (see Fig. 1) from the mouth: Bridge to Skilpadkop (Anderson & Kolberg unpubl.); Sendelingsdrif to Kotzeshoop (Allan & Jenkins 1993), Noordoewer to Haibmond (this study) and the upper Orange River in the Lesotho foothills and highlands (Allan 1999). Species richness values are derived from maximum species counts from any one survey to allow comparison between sites. These counts exclude Cape Wagtails. Up to 15 000 birds have been recorded at the mouth (Simmons 1994) but linear estimates are not possible.

river in a steep-sided gorge. This bird's rarity is confirmed by A. Jenkins (pers. comm.) who found no active nests in 10 years' observations preceding this survey. Storks were present in Lesotho with two birds recorded in 104 km of the lower Senquanyane. The fifth and most unusual Red Data species was a single White-backed Night Heron, *Gorsachius leuconotus*, disturbed from thick riverine vegetation in December 1996.

Raptor fauna

The raptor fauna, including nocturnal species, was relatively rich in this region, with 16 species present (Table 4). Nine of the 16 were seen on the fringes of the river, while 10 occurred over the Karoo plains. Notable finds were the presence of five Booted Eagles along the 50-km stretch of the Orange River – two of these birds were at nest sites in December on cliffs above the river. Breeding could not be confirmed but it has been suspected upstream. Three Red Data birds were present (above) of which the African Fish Eagle, a possible indicator of river health, numbered only five birds in 50 km (one bird per 10 km). Just prior to the study two adult birds were found dead just west of the study area but carcasses were not retained for pesticide analysis. No Fish Eagles were present in the Senqu or lower Senquanyane rivers in Lesotho.

Comparisons with other Namibian rivers

Namibia has only five perennial rivers, all of which have been assessed for avian species richness and abundance using similar methods to the present study. The data (Table 5) indicate that the estimates of between 31 and 55 wetland birds for every 10 km of Orange River are similar to estimates from the only other perennial river crossing the Namib Desert – the Cunene River, 1500 km north. There, wetland bird densities vary between 28 and 37 birds/10 km, and averaged 33 birds/10 km, during December (high flow) counts. However, as expected there is a great disparity between these linear density estimates of the desert rivers and those for tropical rivers in northeastern Namibia running through high-rainfall woodland areas. Tropical woodland rivers sampled with approximately equal intensity, support tenfold more wetland birds than the desert rivers and exhibit slightly

TABLE 4. Raptor species recorded in the Orange River valley and surrounds in 50 km of surveys, December 1996 and April 1997. B = breeding, E = endemic to southern Africa.

Species	Linear density for those occurring along the river	
Booted Eagle*	B, E	Two at nests in 50 km
Black Eagle	B	One nest in 50 km
Augur Buzzard		
Jackal Buzzard	E	
African Fish Eagle	B	Five birds in 50 km
Black-breasted Snake Eagle		
Brown Snake Eagle		
Peregrine Falcon	B	Five pairs in 50 km
Lanner Falcon		
Black-shouldered Kite		
Steppe Buzzard		
Pale Chanting Goshawk		
Rock Kestrel	B	Several pairs
Greater Kestrel		
Cape Eagle Owl**	E	One pair in 50 km
Spotted Eagle Owl		No data

*Southern African breeding subspecies *Hieraetus pennatus capensis*.

**Southern African subspecies *Bubo capensis capensis*.

higher richness values (Table 5). The intermittently flowing Chobe River exhibited the highest densities and species richness values excluding wagtails and kingfishers.

DISCUSSION

Avian species richness derived from this study and Bird Atlas data (Harrison *et al.* 1997) for the middle sections of the lower Orange River was 103 species. These are similar to the only other Namib Desert river for which there are data (the Cunene) but tenfold less than other tropical Namibian rivers. The low species richness in our study area was matched by the findings of Ryan *et al.* (1996) who found only 95 species in total in and around the Orange River further west in the diamond area. They, Winterbottom (1972) and Clancey (1994) each concluded similarly that the Orange River and its immediate surrounds are species-poor, despite its ability to harbour species not typically found in arid desert regions. All authors agree that the low richness of wetland species may result from the high turbidity apparent in this river.

Given the low richness values, does the Orange River nevertheless act as a linear oasis for species not normally occurring in the arid border region of Namibia and South Africa? The higher richness of 71 species found in, or immediately adjacent to, the river compared with surrounding Karoo plains (46 species), supports this prediction. Similarly, in their assessment of terrestrial birds in the 'Sperrgebiet', *c.* 100 km west of this study site, Ryan *et al.* (1996) also found only 50 species of the 95 recorded in total, away from riparian fringes. Could such differences arise from a greater sampling intensity along the river and its fringes? This is unlikely since sampling intensity in this study was greater (12 days) in the Karoo habitats than the riverine habitats (3 days). Thus riverine areas can be confirmed as 54% more species-rich than elsewhere.

More importantly, the Orange River provides critical habitat for the five Red Data species that did not occur outside the immediate river environment. Three of these were wetland species (Black Stork, Fish Eagle and White-backed Night Heron) which are unlikely to be found very far from riverine habitat, while the remaining two (Peregrine and Cape Eagle Owl) were associated with the gorges cut by the river or its immediate tributaries.

TABLE 5. Namibia's rivers compared. Linear density of wetland birds (excluding passerines and kingfishers) and species richness from Namibia's six main perennial rivers. Linear density in bold is given as the mean \pm 1S.D. The first two rivers both cross the Namib Desert for over 300 km, traversing rocky gorges and sandy plains. The remaining rivers are tropical in origin traversing higher rainfall areas through flat woodland savannas. Note the tenfold higher mean densities of the tropical rivers relative to the desert rivers.

River	Length surveyed (km)	Birds counted	Linear density (birds/10 km)	Species richness	Observers
Lower Orange ^a	50	130 (Dec 96)	26	16	R. Simmons
	10	34 (Apr 97)	34	10	R. Simmons
	160	705 (Jul 91)	44	20	Allan & Jenkins 1993
	64	248 (Mar 00)	39	18	A. Hester & S. Edelstein
			36 \pm 8		
Cunene	5	14 (Apr 93)	28	8	D. Ward
	6	18 (Apr 94)	30	8	D. Ward
	22	80 (Nov 97)	37	19	R. Simmons
			32 \pm 5		
Kwando	5	19 (Jul 91)	38	9	J. Tagg
	5	28 (Jan 92)	56	10	J. Tagg
	5	144 (Jan 95)	288	31	M. Holstenson
	5	178 (Apr 96)	356	30	M. Lifasi
	5	104 (Feb 97)	208	22	M. Holstenson
	5	193 (Jan 98)	386	27	W. Oeder
			310 \pm 79^b		
Kavango	2	71 (Apr 90)	355	11	R. Simmons
	2	27 (Jul 92)	135	10	P. Lane
	2	112 (Jan 93)	560	23	P. Lane
	2	62 (Jan 95)	310	17	P. Lane
	2	43 (May 95)	215	10	P. Lane
	2	103 (Apr 96)	515	11	P. Lane
	51	811 (Dec 96)	159	39	D. Allan
			321 \pm 167		
Zambezi	10	221 (Jan 98)	221	22	E. Taylor
	10	429 (Feb 99)	429	32	V. and D. Sparg
	35	1690 (Jul 98)	488	34	L. Scheepers
	10	251 (Apr 00)	251	20	R. and V. Sparg
			347 \pm 131		
Chobe	23	2091 (Aug 98)	925	38	R. Simmons <i>et al.</i> ^c
	40–55	1743 (Dry) ^d	378	36	Herremans 1999
	40–55	399 (Wet) ^e	86	27	Herremans 1999
			463 \pm 426		

^aMiddle sections only – the lower reaches within 20 km of the mouth support higher densities.

^bThe first counts (1991 and 1992) are not included in this average because they may have been pesticide-influenced.

^cIncludes Mark Paxton, Alice Jarvis, Tony Robertson, Dick and Katie Sharpe.

^dMean of six counts in the dry season (June–August 1993/1994).

^eMean of three counts in the wet season (December–March 1993/1994).

Riverine bird density and abundance

The surveys revealed between 31 and 34 wetland birds for every 10 km of river (Table 2). This density was lower than the 55 birds/10 km in Allan & Jenkins (1993) survey just downstream, principally because more Egyptian Geese *Alopochen aegypticus* and Cape, *Motacilla capensis*, and Pied Wagtails, *M. aguimp*, were present there. If one includes only riverine species seen along the Orange River (21 species; Table 2), the 50 km stretch of river surveyed was also slightly less species-rich than their 160 km survey at 25 wetland species. Two wetland birds not seen in this study were Squacco, *Ardeola ralloides*, and Green-backed Herons *Butorides striatus*.

These results are in line with the east–west trend (Fig. 2.) for increased diversity and abundance, and are matched by studies commissioned to re-sample the Allan & Jenkins study area in March 2000. Employing similar methods over 64 km, A. Hester and S. Edelstein (unpubl.) also recorded higher richness (23 species) and linear abundance (73 birds/10 km) than in our study area. Hence, despite downstream regions becoming more and more arid, riverine diversity increases (Fig. 2).

East–west trends

The east–west trend of 11 birds/10 km in Lesotho (Allan 1999) to 406 birds/10 km within 10 km of the mouth (Fig. 2) may arise

for several reasons. First, the river flow is lower in July than in December or April, isolating pools and exposing habitat unavailable at high flow. This may add to both richness and abundance values for the downstream counts done at low water. However this trend was not apparent between the December (low to rising) and April (peak flow) surveys in this study. Neither was it apparent between the March and July surveys downstream of Noordoewer (Allan & Jenkins 1993; A. Hester & S. Edelstein, unpubl.) nor in the Chobe River during wet and dry periods (Herremans 1999). Second, the downstream survey area is more pristine than that around Noordoewer (A. Jenkins, pers. comm.) cutting as it does through protected areas on the South African banks (Fig. 1). There, little or no agriculture is practised and the presence of pesticides is minimal. However, this is also true of Lesotho (where diversity is lowest) where snow melt adds to river flow and pesticide use is absent. The lower diversity further upstream there is unlikely to be explained by human-influenced habitat. The third most probable reason for the increasingly higher diversity as one travels from east to west is that the river is slowing, widening and warming as it descends from the Lesotho highlands. This may create more suitable habitats, richer ecosystems, and allow nutrients to be deposited on the banks and river bed. This is particularly true within 10 km of the mouth where emergent aquatic vegetation occurs on the margins and in the

centre of the river. It is not explained by species becoming concentrated in the river with increasing aridity because only species confined to wetlands were used in this assessment.

Total number of birds along the lower Orange River

Assuming that the density estimates (31, 34, 55 and 73 birds/10 km; average = 48 birds/10 km) derived over 200 km of the 600 km lower Orange River are representative of the remaining lower Orange, we can estimate that about 2900 wetland birds occur along Namibian/South African border river, most of which will be darters, cormorants and the larger herons (Table 2). Within 10 km of the mouth, however, wetland bird densities average about 406 birds/10 km (M. Anderson and H. Kolberg unpubl.), adding an additional 800 birds to the penultimate 20 km of river. The entire Namibian/South African portion of the river holds about 3700 birds. Extrapolations should be treated cautiously, however, since these estimates may change with river conditions and anthropogenic factors such as pesticide use (below). Such surveys also probably miss the smaller and more cryptic species (Allan & Jenkins 1993), and underestimate the nocturnal herons. They are nevertheless among the first published estimates for any river in southern Africa (but see Herremans 1999), and they indicate the importance of the river mouth where total numbers (up to 15 000 birds: Simmons 1994; M. Anderson, in prep.) can exceed the entire lower river in overall abundance.

Pesticides may locally influence species abundance, given that farming of lucerne on the banks of the Orange River is introducing large quantities of pesticides into the system. Farmers use gravity irrigation, pumping water up to their crops, some of which then flows back to the river. At Haibmond, the farm used the organophosphate 'Dipterex' to kill insect pests of lucerne. This is harmful to fish, killing them on contact, and it is not recommended to be used close to waterways by the manufacturers, Bayer. One possible indication that pesticides are affecting the system is that immediately upstream of Haibmond, where there is no agriculture, bird densities at 12.5 birds/km (Table 2) were substantially higher than similar habitat immediately downstream of Haibmond where only 3.0 birds/km were recorded. While this fourfold difference may be an artefact of (slower) sampling against a strong current, the presence of two dead Fish Eagles reported immediately prior to the study, and a dead cormorant during it, from Noordoewer, suggest unnatural causes. The carcasses could not be saved for analysis. These factors, together with the highly regulated nature of the river (Cambray 1984) may indicate that species diversity is compromised by human activities upstream and adjacent to the study areas.

The final possibility that latitudinal differences are influencing avian abundance and species richness is not borne out by a comparison between the Orange and Cunene rivers (Table 5). These two perennial rivers lie 10° apart at opposite ends of Namibia, yet their average linear wetland bird densities are almost identical (36 versus 32 birds/10 km respectively). The main anthropogenic difference between these rivers is the lack of agriculture or pesticide use along the Cunene River.

Red Data species

All five Red Data species were associated with the Orange River. Of these the White-backed Night Heron was least expected. This is a bird of tropical rivers and is unexpected in more temperate regions such as the Orange River (Martin 1997). However, single birds have been noted before by both Winterbottom (1971) in the Fish River and by Shaughnessy & Shaughnessy (1980) on the Orange River at Aussenkehr (Richtersveld). No sightings have occurred in the last 19 years

and no birds were reported during bird atlassing (Martin 1997). It is classed as critically endangered in Namibia (Brown *et al.* 1997) and South Africa (Barnes 2000) and in 15 years' of bird atlassing was recorded only five times throughout Namibia. This bird clearly represents a highly isolated pocket but their nocturnal habits and thick riverine habitat means that they are easily overlooked. It was not seen in April 1997 but suitable habitat is available along large stretches of the Orange River and it may be resident.

The Black Stork is also a rare resident in southern Africa, and populations are scattered through rugged habitat where suitably high cliffs and permanent water is available. About 200 pairs are thought to exist in southern Africa (Allan 1997). The Kuiseb River, a dry ephemeral river in central Namibia harbours about 13 storks in 110 km, or 1.2 birds/10 km of river (Tilson & Kok 1980). While this survey revealed only one bird in 50 km, the three nest sites seen give a potential density of six birds in 50 km (1.2 birds/10 km), exactly the density found in the Kuiseb. Allan & Jenkins' (1993) survey revealed 0.5 storks/10 km further downstream where suitable cliff sites are less frequent and Allan (1999) reported 0.2 storks/10 km in Lesotho.

Raptors

Booted Eagles are uncommon breeders in southern Africa (Anderson *et al.* 1995) and nests are hard to find (Brown 1985). Since they begin breeding in September (Steyn 1982) they would be expected at their nest sites in December during these surveys. The occurrence of five birds and two possible nest sites downstream of Haibmond suggests an overlooked occupation and breeding habitat. The bird is known from the Richtersveld, just west of the study area (Davidson 1982; Boshoff & Allan 1997), but breeding has not been confirmed. Further sampling will determine if this is a new breeding locality for this species and thus the second known, after the Waterberg Plateau, for Namibia (Brown 1985).

Cape Eagle Owls of the race *Bubo capensis capensis* are southern African endemics and considered 'vulnerable' in Namibia (Steyn 1982; Brown *et al.* 1997). They have only been recorded nine times in Namibia during the 15-year atlassing period, and only one breeding record is known from Lüderitz (Walter *et al.* 1986). The lower Orange is appropriate habitat for these birds since it is both steep and rugged and their main prey, the Smith's Red Rock Rabbit, *Pronolagus rupestris*, occurs there (M. Griffin, pers. comm.). Population size is unknown but other birds have been recorded calling further west in gorges associated the Orange River (A. Jenkins & A. Hester, pers. comm.).

Peregrine Falcons were seen relatively commonly along the Orange River, and the lower Orange may support as many as 10–15 pairs along its total length (A. Jenkins, pers. comm.). The high cliffs, low disturbance and concentrated prey populations all add to the attraction of the Orange River to this relatively rare species.

To summarize, the paucity of avifaunal knowledge of southern Africa's rivers precipitated this survey of its longest river, the Orange. Species richness in riparian habitat was 54% higher than in the surrounding arid Karoo, proving its linear oasis effect. The lower Orange was also rich in both Red Data and raptorial species. Linear density and species richness estimates were similar to the Cunene River – the only other perennial Namib Desert river – but tenfold lower than tropical woodland rivers in Namibia. The relatively low abundance may be a natural phenomenon associated with its high turbidity and the low visibility afforded to piscivorous species. The trend for increasingly high linear density and species richness evident from its mountain source in Lesotho to its mouth on the Namib Desert coast may arise from the river becoming wider, warmer

and slower, despite the rapidly increasing aridity. Bird numbers at the mouth exceed the entire estimated total population of the lower Orange, making it the single most important section of the river. Further sampling at different seasons and in different areas will clarify the critical factors and we appeal to others not to overlook the biological diversity of southern Africa's rivers.

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