

Surveys of riverine birds along the Ayeyarwady River in 2017–2019 and conservation implications

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The Ayeyarwady River, Myanmar, is exceptionally important for waterbirds and other riverine species. Results from mid-winter boat-based surveys in 2017–2019 demonstrated the high conservation value of the river’s avifauna. We recorded a total of 83 waterbird species and 18 species listed as Globally Threatened (7) or Near Threatened (11) under IUCN criteria, 16 of which were waterbirds. Counts of many waterbird species were in numbers high enough for the designation of seven river sections as Wetlands of International Importance under the Ramsar Convention on Wetlands. The middle reaches of the Ayeyarwady River between Myitkyina and Bagan hosted more than 40,000 waterbirds in 2019, qualifying this stretch for Ramsar designation under Criterion 5. However, these numbers were already considerably reduced compared to those regularly observed in similar surveys between 2000 and 2007. Species present in this earlier period, such as Masked Finfoot *Heliopais personatus*, Spot-billed Pelican *Pelecanus philippensis* and Black-necked Stork *Ephippiorhynchus asiaticus*, were not recorded during the more recent surveys, and appear to have declined or disappeared. The waterbird species with the highest counts were Ruddy Shelduck *Tadorna ferruginea*, Cattle Egret *Bubulcus ibis* and Little Pratincole *Glareola lactea*, but counts of the shelduck and the pratincole have declined in recent years. Some nesting species, such as the Globally Threatened Black-bellied Tern *Sterna acuticauda* and River Tern *S. aurantia*, appear to be on the brink of extinction on this river, and Indian Skimmer *Rynchops albicollis* may have already been lost as a breeder. The river is subject to a wide range of increasing pressures from a growing human population, including agriculture, gold mining, sand and pebble abstraction and poaching, and high levels of disturbance associated with these activities, contributing to apparent declines of several species. Recommendations for urgent conservation action include the designation of Ramsar sites, and establishment of community-based conservation areas.

INTRODUCTION

The Ayeyarwady River is one of the only remaining large rivers in Asia with no dams and relatively low levels of human impact, and remains important for biodiversity, including many bird species that have drastically declined in other parts of South-East Asia (Dudgeon 2000, Chowdhury *et al.* 2014, Debata *et al.* 2019), such as the Black-bellied Tern *Sterna acuticauda* and large numbers of wintering waterbirds. The river level fluctuates by five to six metres between the rainy and dry seasons (Walker 2017). It has one of the highest sediment flows in the world (WWF 2017) and supports diverse habitats for birds and biodiversity in general. Its sandbars and associated riverine wetlands create numerous habitats for birds, fish and other animals (Zöckler & Kottelat 2017). The river was partially surveyed in colonial times (e.g. Oates 1888, Harington 1909–1910, 1911, Stanford & Ticehurst 1938–1939), though no numbers of birds were recorded. The reports of these early explorers provided a window into a little-disturbed river system and adjacent wetlands that still hosted a number of species that have disappeared today, including the Pink-headed Duck *Rhodonessa caryophyllacea* which may by now be globally extinct (Tordoff *et al.* 2008). More comprehensive surveys and counts of most waterbird species have been conducted more recently (e.g. van der Ven 2000, 2001a,b, 2003, 2004, Davies *et al.* 2004, Thet Zaw Naing & Ngwe Lwin 2006, Thet Zaw Naing 2009, Harrison Institute 2015). Similar but less detailed surveys have been undertaken on the Chindwin River, a major tributary of the Ayeyarwady (Thet Zaw Naing *et al.* 2017), and further upstream on the Ayeyarwady by Tordoff *et al.* (2007).

The Ramsar Convention on Wetlands, signed in Ramsar, Iran, in 1971, provides nine criteria to use in the assessment and designation of Wetlands of International Importance. The Ramsar criteria relevant to the assessment of the importance of the Ayeyarwady River for waterbirds are as follows:

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Figure 1. Ayeyarwady River sections surveyed in 2017–2019 following Davies *et al.* (2004) and distribution of Red-listed species along the Ayeyarwady River.

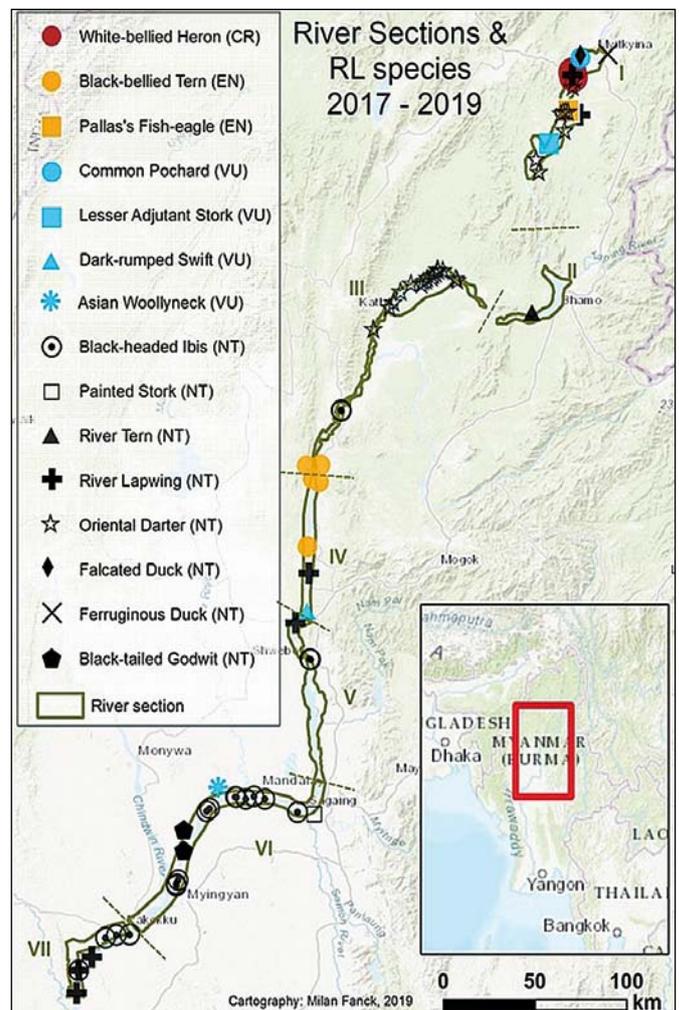


Table 1. Ayeyarwady River sections between Myitkyina and Bagan according to Davies *et al.* (2004) and our observations (see also Figure 1), and their international importance based on Ramsar criteria 2, 4, 5 and 6 (Wetlands International 2012) for the 2017–2019 survey period.

Abbreviations: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near-Threatened.

No.	River section and length in km	Key characteristics	Criterion 2 (threatened species)	Criterion 4 (critical life cycle stage)	Criterion 5 (20,000 waterbirds threshold)	Criterion 6 (1% of flyway population)	Historical significance
I	Myitkyina–Sinbo (95)	Floodplain with adjacent wetlands and oxbow lakes, serious erosion	White-bellied Heron (CR), Pallas's Fish-eagle (EN), Lesser Adjutant (VU), Common Pochard (VU)	Little Pratincole breeding colonies	-/-	Ruddy Shelduck (2–2.1%); Bar-headed Goose (1.8%, 2019); Little Pratincole (2–4%)	Masked Finfoot and White-bellied Heron (van der Ven 2001a,b), Spot-billed Pelican, Black-necked Stork (Davies <i>et al.</i> 2004)
II	Bhamo–Shwegu (45)	Outwash floodplain	Irrawaddy Dolphin (CR)	River Tern breeding colony	-/-	-/-	Pink-headed Duck (Harington 1909–1910), White-bellied Heron and Baer's Pochard (Smythies 1953)
III	Shwegu–Katha–Takaung (107)	Long stretch of large floodplain with huge sandbanks and steep banks, some reedbeds and gorge near the end towards Tagaung	Irrawaddy Dolphin (CR)	Little Pratincole breeding colonies	-/-	Ruddy Shelduck (~5%); Little Pratincole (2%)	Masked Finfoot in 1920s among others (BirdLife International 2001)
IV	Takaung–Singhu (70)	Continuation of gorge but open, wide floodplain areas in between with large sandbanks and oxbow lakes	Black-bellied Tern (EN), Irrawaddy Dolphin (CR), Dark-rumped Swift (VU)	Little Pratincole and Black-bellied Tern breeding colonies	-/-	Ruddy Shelduck (2%); Little Pratincole (2%)	Large Black-bellied Tern colonies (Davies <i>et al.</i> 2004)
V	Singhu–Mandalay (20)	Wide channel with large sandbanks and river arms in open floodplain	Irrawaddy Dolphin (CR)	Little Pratincole breeding colonies	-/-	Ruddy Shelduck (3.5%); Glossy Ibis (1.8%); Little Pratincole (4%)	Pink-headed Duck in 1908 (Smythies 1953)
VI and VII	Mandalay–Bagan (150)	Large, wide, open main channel with large sandbanks and many smaller braided river channels	Yellow-breasted Bunting (CR), Woolly-necked Stork (VU), Black-bellied Tern (EN) (WCS, Lay Win <i>in litt.</i>)	Little Pratincole breeding colonies	22,500 (2019)	Ruddy Shelduck (5.2–7.4%); Northern Pintail (~1%); Indian Spot-billed Duck (2.9%); Black-headed Ibis (1–2.5%); Glossy Ibis (1.2%); Common Crane (1.1%); Little Pratincole (1.3%)	Baer's Pochard 2001 (Wetlands International 2001), Great Thick-knee (Lay Win <i>in litt.</i> 2017)

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Myanmar became a party to the Ramsar Convention in 2005, and had designated six sites totalling almost 300,000 ha in extent by 2020.

In order to provide updated and comprehensive knowledge about the biodiversity of the large river systems in Central Myanmar as a basis for future planning and conservation, several fish and bird surveys were undertaken, initially in 2017 as part of the World Bank funded State of the Ayeyarwady River Basin Assessment (SOBA) and later in 2018 and 2019 on behalf of Fauna and Flora International (FFI) and the Manfred-Hermesen Foundation (MHS) (Zöckler 2019). Here we report on these surveys in 2017, 2018 and 2019, which used a similar methodology to that of the 2001–2003 surveys, at similar mid-winter periods to those reported by van der Ven (2000, 2001a,b, 2003, 2004) and Davies *et al.* (2004). The similarity in approaches between the two sets of surveys offers possibilities for a cautious assessment of changes in numbers, and comparison of the present avifauna with that of the 2001–2003 period and before. The region is rich in waterbirds and other bird species, and a selection of other noteworthy observations have been included in the assessment.

METHODS

Study area

The Ayeyarwady River flows for over 2,200 km from the Hkakaborazi Mountains to the vast Ayeyarwady delta. The three-season bird survey covered the 500 km-long middle reaches of the river between Myitkyina and Bagan. The entire river stretch between Myitkyina and Bagan was divided into seven discrete sections (see Figure 1 and Table 1). This was largely in accordance with the areas defined by Davies *et al.* (2004) and Wetlands International's International Waterbird Census (IWC).

The topography and climate of the Ayeyarwady catchment are responsible for a flood pulse system that accounts for a high volume of water passing through the area. Much of the Ayeyarwady River (sections II–VII; Figure 1) is a typical floodplain river, characterised by long stretches of braided channels, sandy bars, islands and banks. The meandering stretches are typified by these braided channels, which characterise most of the river from the end of the first gorge near Bhamo to Bagan and further to the delta. Section I is also a floodplain river, meandering but with sediment types consisting of larger pebbles of 10–20 cm in size on average that are missing entirely in sections II to VII. In the rainy season, high water floods most of the braided channels, leaving only some of the higher elevation islands exposed in the middle of the river, and creating extensive seasonal wetlands within the river channel, such

as seasonal marshes, low-lying lakes, numerous cut-off channels and oxbow lakes (Lee & Zöckler 2017).

The Ayeyarwady is mostly about 700–800 m wide along the floodplain sections of the river, with depths of approximately 12 to 18 m in the wet season. River banks on the outside of bends in the river are approximately 5 to 7 m high. Habitat heterogeneity is shown by a wide range of different sediments, ranging from fine sand to large pebbles, especially in section I, and rich bank vegetation dominated by reeds, rushes and shrubs (Lee & Zöckler 2017).

Erosion along the Ayeyarwady is evident in many locations, and human activity is increasing. Loose sediments, deposited along the river during high flows, are often rich in nutrients and can become covered by grasses, reeds, shrubs and trees. These areas may become flooded during periods of high flow and are often temporarily used for crops and grazing cattle, with accompanying seasonal human settlements. Gold panning and dredging are widespread in sections I and III, with groups of people turning over the river sediments, working gradually through almost all sediments during one dry season. Sand extraction is less frequent, but was observed in sections III and IV, using large boats. Small fishing camps have also been found scattered along all river sections.

Survey period and methods

The surveys along the Ayeyarwady River were conducted in the dry season at a similar time each year (2–16 February 2017, 23 January–5 February 2018 and 2–13 February 2019), following one day on 11 February 2016 in the Myitkyina region. Long stretches of the river between sections I and II, and III and IV, are gorges, comprising a total length of 150 km, which were largely devoid of waterbirds and so were surveyed rapidly.

The surveys were conducted by boat downstream from Myitkyina to Bagan and on foot at selected sites. Bird observations were made using binoculars (10x40 and 8x32) as well as zoom telescopes (25–60x85). Observations were made from the boat at low engine speed or drifting downstream, although, as with all boat-based surveys, telescope observations were hampered by boat vibrations and movement. Excursions on foot were undertaken in areas with potentially high densities of waterbirds, such as hidden oxbow lakes, in order to establish a more comprehensive picture of the bird distribution along the river and floodplain. At least 12 overnight searches were made over the three seasons to maximise opportunities of encountering crepuscular species such as thick-knees and rails.

Due to local insurgencies, some river sections were not accessible in some years and the gorge between Sinbo and Bhamo was not passable in any of the survey years. Civil unrest also prevented us from surveying the southernmost 25 km of section I in 2018. In section II, the insurgencies prevented coverage of 5 km of suitable habitat in 2017 and 2018, but surveys in 2019 were possible. All other sections were surveyed for a similar amount of time each year, and by at least one surveyor in all years, to maximise the validity of year to year comparisons.

Nomenclature, methods and trend estimation

Taxonomy and nomenclature used in this paper follow BirdLife International (2019a). The term ‘waterbird’ is used as defined by the Ramsar Convention, namely ‘species of bird that are ecologically dependent on wetlands’ as listed in Wetlands International (2012). Selected wetland-associated raptors and passerines are also included.

All bird species were recorded and all water and riverine bird species were counted and geo-referenced using a KOBO smart phone app and the open-source Geographic Information System QGIS. Bird counting on such a scale inevitably misses a proportion of the birds, but it is considered safe to assume that the standardisation of methods between our surveys and those of the early 2000s ensured that a similar proportion of birds was generally missed by each survey. Surveys in each period used similar boats, covered the same river stretches, using the same channels, varied only slightly in the overnight locations, and were

conducted by experienced waterbird surveyors (Davies *et al.* 2004). This means that cautious analyses of relative numbers of each species and trends between years are valid, even if count totals usually underestimate the actual number of birds present. Especially in areas where the river flows through wide, braided river arms, only the main channel was surveyed, but the vantage point on the boat was high enough to ensure that sizeable areas along adjacent river branches were included.

One of the most common riverine birds, Little Pratincole *Glareola lactea*, is very vocal but cryptic when roosting and loafing, and well-camouflaged on the riverine substrate. This bird might have been underestimated in all years but the detection error is likely to have been similar across survey years and similar to previous surveys that covered the same river stretches.

Trend data were estimated for river section I between Myitkyina and Sinbo, which has been surveyed in several years since 2000 (van der Ven 2000, 2001a,b, 2003, Davies *et al.* 2004, Thet Zaw Naing & Ngwe Lwin 2006, Thet Zaw Naing 2009), allowing estimation and comparison of trends in numbers for the most frequently occurring waterbird species. Count data are presented in simple histograms showing the number of each species counted in each year, and regression lines have been calculated and presented to facilitate interpretation of the trends. However, it should be stressed that the assumptions of regression analysis are not fully met by the data.

RESULTS

Altogether, 249 bird species were observed over the three-year survey period, of which 192 species were seen in 2017, 177 in 2018 and 188 in 2019. A total of 83 species of waterbirds were recorded in all three years combined (Table 2). The total number of 40,088 waterbirds recorded in 2019 was considerably higher than the 29,077 individuals in 2018 and 31,792 in 2017. The highest total counts per species were for Ruddy Shelduck *Tadorna ferruginea* (9,147 in 2018) and Little Pratincole (7,212 in 2018), but also Cattle Egret *Bubulcus ibis* with over 7,300 individuals in the lower part of the survey area in 2019. Other common waterbirds included Indian Spot-billed Duck *Anas poecilorhyncha* (total count of 4,513 in 2019), Northern Pintail *Anas acuta* (3,031 in 2017) and Great Cormorant *Phalacrocorax carbo* (1,488 in 2019). Some waterbird species appear to have declined between 2001–2004 and 2017–2019 (Table 2). However, factors such as natural fluctuations in numbers and distribution within the wider region, and possible differences in detectability of some species between surveys, mean that the results of large-scale surveys such as these should be treated with caution (Table 2).

Red Listed species

Of the total of 249 bird species recorded, 18 are listed as Globally Threatened on the IUCN Red List of Threatened Species (<https://www.iucnredlist.org>). Of these 18 species, seven are in the Globally Threatened categories and 11 are classified as Near Threatened. An additional 14 Globally Threatened species (including three in the Near Threatened category and the probably extinct Pink-headed Duck) have historical records, but remained unrecorded during the 2017–2019 surveys, leading to a total of 32 Globally Threatened and Near Threatened species historically and currently recorded along the Ayeyarwady River (Table 3). Seven of these species are Critically Endangered (CR) and three have not been recorded in Myanmar for at least 10, 60 or 80 years, respectively (marked with * in Table 3).

The status of six of these Globally Threatened and two of the Near Threatened species recorded during the 2017–2019 surveys is discussed below.

White-bellied Heron *Ardea insignis* (CR)

Smythies (1953) noted this species as a still not uncommon resident in the north, but rare in central and southern Burma. On 23

Table 2. Waterbird count totals in 2017–2019 on the Ayeyarwady River between Myitkyina and Bagan (sections I to VII). Estimated long-term trends in count totals are included where complete data sets are available in Davies *et al.* (2004) and Thet Zaw Naing & Ngwe Lwin (2006); **bold and underlined**: strong decline in count total of >50% between the early century and 2017–2019 datasets.

Abbreviations: DEC – declining; INC – increasing.

Species	IUCN status	2017	2018	2019	Average (rounded)	Average 2001–2003 (2006)*	Long-term trend estimate
Lesser Whistling-duck <i>Dendrocygna javanica</i>		0	100	190	97	–	
Bar-headed Goose <i>Anser indicus</i>		106	2	1102	403	–	
Greylag Goose <i>Anser anser</i>		156	103	517	259	–	
Greater White-fronted Goose <i>Anser albifrons</i>		10	2	0	4	–	
Common Goldeneye <i>Bucephala clangula</i>		5	8	12	8	–	
Goosander <i>Mergus merganser</i>		9	7	23	13	120	DEC
Red-breasted Merganser <i>Mergus serrator</i>		3	0	0	1	–	
Common Shelduck <i>Tadorna tadorna</i>		5	41	4	17	2	INC
Ruddy Shelduck <i>Tadorna ferruginea</i>		7,865	9,147	7,337	8,116	8,804	DEC?
Comb Duck <i>Sarkidiornis melanotos</i>		0	2	26	9	–	
Mandarin Duck <i>Aix galericulata</i>		1	0	0	0	–	
Red-crested Pochard <i>Netta rufina</i>		0	1	6	2	–	
Common Pochard <i>Aythya ferina</i>	NT	3	0	1	1	1,000	DEC
Ferruginous Duck <i>Aythya nyroca</i>	NT	1	0	1	1	1,500	DEC
Tufted Duck <i>Aythya fuligula</i>		0	0	12	4	–	
Garganey <i>Spatula querquedula</i>		1	0	109	37	–	
Northern Shoveler <i>Spatula clypeata</i>		5	6	50	20	–	
Falcated Duck <i>Mareca falcata</i>	NT	2	0	2	1	–	
Gadwall <i>Mareca strepera</i>		986	637	485	703	2,364*	DEC
Eurasian Wigeon <i>Mareca penelope</i>		2	37	3	14	–	
Indian Spot-billed Duck <i>Anas poecilorhyncha</i>		3,741	2,914	4,513	3,723	1,388*	INC
Mallard <i>Anas platyrhynchos</i>		784	307	99	397	–	
Northern Pintail <i>Anas acuta</i>		3,031	984	2,173	2,063	–	
Common Teal <i>Anas crecca</i>		64	448	38	183	–	
Little Grebe <i>Tachybaptus ruficollis</i>		3	0	0	1	–	
Great Crested Grebe <i>Podiceps cristatus</i>		10	17	25	17	–	
Slavonian Grebe <i>Podiceps auritus</i>		1**				1	
Black-necked Grebe <i>Podiceps nigricollis</i>		0	2	0	1	–	
Watercock <i>Gallinula cinerea</i>		0	0	1	0	–	
White-breasted Waterhen <i>Amaurornis phoenicurus</i>		7	0	1	3	–	
Common Moorhen <i>Gallinula chloropus</i>		6	0	0	2	–	
Common Crane <i>Grus grus</i>		425	207	1,054	562	1,481	DEC
Lesser Adjutant <i>Leptoptilos javanicus</i>	VU	0	0	1	0	10	DEC
Painted Stork <i>Mycteria leucocephala</i>	NT	2	0	0	1	–	
Asian Openbill <i>Anastomus oscitans</i>		725	720	1,118	854	–	
Black Stork <i>Ciconia nigra</i>		75	106	99	93	233	DEC
Asian Woollyneck <i>Ciconia episcopus</i>	VU	11	0	0	4	–	
Black-headed Ibis <i>Threskiornis melanocephalus</i>	NT	100	20	249	123	–	
Glossy Ibis <i>Plegadis falcinellus</i>		264	727	697	563	0	INC
Black-crowned Night-heron <i>Nycticorax nycticorax</i>		5	22	5	11	–	
Indian/Chinese Pond-heron <i>Ardeola grayii/bacchus</i>		58	24	31	38	–	
Cattle Egret <i>Bubulcus ibis</i>		1,109	1,664	7,305	3,359	–	
Grey Heron <i>Ardea cinerea</i>		442	427	376	415	–	
White-bellied Heron <i>Ardea insignis</i>	CR	0	1	0	0	–	
Great Egret <i>Ardea alba</i>		192	165	503	287	–	
Intermediate Egret <i>Mesophoyx intermedia</i>		10	10	11	10	–	
Little Egret <i>Egretta garzetta</i>		846	349	337	511	–	
Little Cormorant <i>Phalacrocorax niger</i>		720	256	831	602	–	
Great Cormorant <i>Phalacrocorax carbo</i>		1,375	920	1,488	1,261	1,645	DEC?
Oriental Darter <i>Anhinga melanogaster</i>	NT	39	22	46	36	74	DEC
Pied Avocet <i>Recurvirostra avosetta</i>		12	0	5	6	–	
Black-winged Stilt <i>Himantopus himantopus</i>		1	0	15	5	–	
Common Snipe <i>Gallinago gallinago</i>		14	0	2	5	–	
Pacific Golden Plover <i>Pluvialis fulva</i>		339	77	77	164	–	
Little Ringed Plover <i>Charadrius dubius</i>		295	300	505	367	–	
Kentish Plover <i>Charadrius alexandrinus</i>		359	425	1,022	602	–	

Species	IUCN status	2017	2018	2019	Average (rounded)	Average 2001–2003 (2006)*	Long-term trend estimate
Lesser Sandplover <i>Charadrius mongolus</i>		164	91	12	89	–	
Northern Lapwing <i>Vanellus vanellus</i>		63	14	96	58	–	
River Lapwing <i>Vanellus duvaucelii</i>	NT	27	2	2	10	58*	DEC
Grey-headed Lapwing <i>Vanellus cinereus</i>		38	0	7	15	–	
Eurasian Curlew <i>Numenius arquata</i>	NT	0	0	1	0	7	
Black-tailed Godwit <i>Limosa limosa</i>	NT	26	0	0	9	–	
Ruff <i>Calidris pugnax</i>		13	1	0	5	–	
Temminck's Stint <i>Calidris temminckii</i>		514	138	503	385	178*	
Red-necked/Little Stint <i>Calidris ruficollis/minuta</i>	NT	2	60	693	252	–	
Dunlin <i>Calidris alpina</i>		41	13	18	24	–	
Common Sandpiper <i>Actitis hypoleucos</i>		60	48	69	59	–	
Green Sandpiper <i>Tringa ochropus</i>		18	12	14	15	–	
Spotted Redshank <i>Tringa erythropus</i>		314	132	293	246	–	
Common Greenshank <i>Tringa nebularia</i>		87	70	129	95	66*	
Common Redshank <i>Tringa totanus</i>		0	11	1	4	–	
Wood Sandpiper <i>Tringa glareola</i>		2	3	104	36	–	
Oriental Pratincole <i>Glareola maldivarum</i>		1	0	0	0	–	
Little Pratincole <i>Glareola lactea</i>		5,920	7,212	5,629	6,254	8,794	DEC
Brown-headed Gull <i>Larus brunnicephalus</i>		196	4	1	67	–	
Great Black-headed Gull <i>Larus ichthyaetus</i>		69	60	58	62	163*	DEC
Little Tern <i>Sternula albifrons</i>		5	1	16	7	11*	
River Tern <i>Sterna aurantia</i>	VU	2	2	3	2	81*	DEC
Black-bellied Tern <i>Sterna acuticauda</i>	EN	3	3	5	3	13*	DEC
Osprey <i>Pandion haliaetus</i>		35	38	30	34	–	
Common Kingfisher <i>Alcedo atthis</i>		6	3	5	5	–	
Pied Kingfisher <i>Ceryle rudis</i>		93	79	94	88	–	
White-breasted Kingfisher <i>Halcyon smyrnensis</i>		14	7	13	11	–	

*= counts did not cover all river sections and hence higher numbers are likely.

**=observed in 2016.

January 2018, an immature White-bellied Heron was observed and photographed on the Ayeyarwady River bank not far from Myitkyina (Figure 1, Plate 1). A second observation probably involving the same individual was reported by Nyein Chan (pers. comm.) on 26 March 2018 in the same area. These records constitute the first and second observations anywhere along the river since 2013. Table 4 summarises all known records of this species. It seems possible that young birds from Nam Sam Chaung still regularly visit the Ayeyarwady River.

Pallas's Fish-eagle *Haliaeetus leucoryphus* (Endangered [EN])

The only record from 2017–2019 was of one immature bird near Talaw Gyi in section I on 6 February 2017 (Figure 1). This species breeds widely across Central and East Asia, but it is today very rarely observed in Myanmar, and its status as a breeding bird is not confirmed. Smythies (1953) still described it as 'the common fish eagle along the Irrawaddy River', also nesting near Myitkyina. Davies *et al.* (2004) mentioned only single birds from Lake Indawgyi, from where NL noted a few unconfirmed records more recently in 2014. A juvenile bird carrying a satellite-tracking device travelled from Mongolia to Myanmar in three consecutive winters prior to 2017 (Steele 2017). The species was uplisted to EN in 2019 (BirdLife International 2019a), which is consistent with the absence of records from the Ayeyarwady River during 2018–2019.

Black-bellied Tern *Sterna acuticauda* (EN)

Three birds, including one apparent pair, were observed in section IV in 2018 and 2019 (Plate 2). The pair were displaying and defending a breeding territory from Grey Herons *Ardea cinerea*. A WCS nest guarding and protection scheme identified another three or four pairs in section IV, which raised a total of five hatchlings in March 2018 (A. Diment, *in litt.* 2018). In 2019, a nest containing

three eggs was found near Takaung in section IV on 5 February by WCS (Naing Lin, pers. comm.), indicating the beginning of the breeding season at this time. Numbers appear to have declined since 2003, when 13 birds were recorded in early February in section III alone (Davies *et al.* 2004).

Lesser Adjutant *Leptoptilos javanicus* (Vulnerable [VU])

The only recorded Lesser Adjutant was one on 3 February 2019 near Sinbo in section I (Figure 1). The most recent record prior to this was a single individual in 2007, also in section I (van der Ven & Thet Naw Zaing 2007). Van der Ven (2001b) recorded four birds on 12 December 2001, and between 27–30 January 2003 the river stretch between Myitkyina and Sinbo held 14 birds (Davies *et al.* 2004).

Asian Woollyneck *Ciconia episcopus* (VU)

There was only one record, on 13 February 2017, from Si Moo Khon in section VI, where 11 birds were roosting on a sandbank. The species is regarded as being in decline (BirdLife International 2019b). Davies *et al.* (2004) and van der Ven & Thet Zaw Naing (2007) each reported two from section I, from where the species was absent in the recent surveys.

Dark-rumped Swift *Apus acuticauda* (VU)

On 9 February 2019, a mixed flock of 20–30 swifts including Fork-tailed Swifts *Apus pacificus* and 15–20 Dark-rumped Swifts were observed in the gorge near Thabeikkyin in section IV (Zöckler *et al.* 2019, Figure 1). The species is regarded as Globally Threatened due to its restricted range and small population (BirdLife International 2019c).

River Tern *Sterna aurantia* (VU)

A pair of River Terns was observed at one location on the river sandbars near Bhamo in section II in all three survey years (Plate 3).

CHRISTOPH ZÖCKLER



Plate 1. White-bellied Heron *Ardea insignis*, Ayeyarwady River near Myitkyina, Myanmar, 23 January 2018.



Plate 2. Black-bellied Tern *Sterna acuticauda*, Ayeyarwady River, 8 February 2019.

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Plate 3. River Tern *Sterna aurantia*, Ayeyarwady River, Bhamo area, 28 January 2018.



Plate 4. River Tern nest, Ayeyarwady River, Bhamo area, 5 February 2019.

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Plate 5. Ruddy Shelduck *Tadorna ferruginea*, Ayeyarwady River, 29 January 2018.



Plate 6. Bar-headed Goose *Anser indicus*, Ayeyarwady River near Myitkyina, 13 February 2016.

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Plate 7. Indian Spot-billed Duck *Anas poecilorhyncha*, Ayeyarwady River, 6 February 2019.



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Plate 8. Black Stork *Ciconia nigra* and Greylag Goose *Anser anser*, Ayeyarwady River near Talawgyi, 4 February 2017.



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Plate 9. Pied Kingfisher *Ceryle rudis*, Ayeyarwady River, 31 January 2019.



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Plate 10. Little Pratincole *Glareola lactea*, Ayeyarwady River, 29 January 2018.



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Plate 11. Long-legged Buzzard *Buteo rufinus*, U Laut, Ayeyarwady River, 24 January 2018.



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Plate 12. Merlin *Falco columbarius*, Ayeyarwady River, 7 February 2019.

Table 3. Globally Threatened bird species recorded along the Ayeyarwady River between Myitkyina–Bagan in 2017–2019; additional species listed (shaded) were recorded prior to 2017 or outside the actual surveys.

Abbreviations: CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near-Threatened.

Species	Red List category	Most recent year(s) recorded	Comment
Pink-headed Duck* <i>Rhodonessa caryophyllacea</i>	CR	1910	Wetlands near Singu (Smythies 1953, Tordoff <i>et al.</i> 2008)
White-shouldered Ibis* <i>Pseudibis davisoni</i>	CR	1906	'Fairly common' Macdonald (1906)
White-bellied Heron <i>Ardea insignis</i>	CR	2018	First record since 2013 (near Bhamo, Thet Zaw Naing <i>in litt.</i>)
Baer's Pochard <i>Aythya baeri</i>	CR	2001	Near Naung U (IWC)
White-rumped Vulture <i>Gyps bengalensis</i>	CR	2001, 2003	van der Ven (2001b), Davies <i>et al.</i> (2004)
Slender-billed Vulture <i>Gyps tenuirostris</i>	CR	2003, 2004	Davies <i>et al.</i> (2004), van der Ven (2004)
Yellow-breasted Bunting <i>Emberiza aureola</i>	CR	2017	Bagan (Lay Win, pers. comm.)
Greater Adjutant* <i>Leptoptilos dubius</i>	EN	1940s	Shwebo and Myingyin (Roseveare 1949)
White-winged Duck <i>Asarcornis scutulata</i>	EN	1909, 2001	Bhamo (Harington 1909–1910), January 2001 at Nam Sam Chaung (van der Ven 2001a)
Masked Finfoot <i>Heliopais personatus</i>	EN	1927, 2001	Near Shwegu and Katha, near Tagaung (Smith 1942, Smythies 1953), 2001 at Nam Sam Chaung (van der Ven 2001b)
Black-bellied Tern <i>Sterna acuticauda</i>	EN	all	
Pallas's Fish-eagle <i>Haliaeetus leucorhynchus</i>	EN	2017	Near U Laut
Indian Skimmer <i>Rhynchops albicollis</i>	EN	2001, 2019	Single birds in 2001 (section VI, Davies <i>et al.</i> 2004) and one in V (Naing Lin, pers. comm.); formerly (1929) breeding bird near Katha (Smith 1942)
Common Pochard <i>Aythya ferina</i>	VU	2017, 2019	
Lesser Adjutant <i>Leptoptilos javanicus</i>	VU	2019	Near Sinbo
Asian Woollyneck <i>Ciconia episcopus</i>	VU	2017	Near Si Mee Khon
Greater Spotted Eagle <i>Aquila clanga</i>	VU	2001	Naung U (IWC)
River Tern <i>Sterna aurantia</i>	VU	all	
Dark-rumped Swift <i>Apus acuticauda</i>	VU	2019	First record near Thabeikkyin
Black-necked Stork <i>Ephippiorhynchus asiaticus</i>	NT	2004	van der Ven (2001a), Davies <i>et al.</i> (2004)
Spot-billed Pelican <i>Pelecanus philippensis</i>	NT	2007	222 in 2000 and 70 in 2007 (van der Ven 2000, van der Ven & Thet Zaw Naing 2007)
Great Thick-knee <i>Esacus recurvirostris</i>	NT	2001	Up to 9 birds (van der Ven 2001a)
Falcated Duck <i>Anas falcata</i>	NT	2017, 2019	First records since 2007 (van der Ven & Thet Zaw Naing 2007)
Ferruginous Duck <i>Aythya nyroca</i>	NT	2017, 2019	
Painted Stork <i>Mycteria leucocephala</i>	NT	2017	
Black-headed Ibis <i>Threskiornis melanocephalus</i>	NT	all	
Oriental Darter <i>Anhinga melanogaster</i>	NT	all	
Himalayan Griffon <i>Gyps himalayensis</i>	NT	2019	First record since 2003 (Davies <i>et al.</i> 2004)
River Lapwing <i>Vanellus duvaucelii</i>	NT	all	
Eurasian Curlew <i>Numenius arquata</i>	NT	2019	Only once; previously more common (7 birds in February 2004; van der Ven 2004)
Black-tailed Godwit <i>Limosa limosa</i>	NT	2017	Irregularly
Red-necked Stint <i>Calidris ruficollis</i>	NT	all	Relatively common but mixed with Little Stint

* Species not recorded for at least 80 years.

Table 4. Known records of White-bellied Heron *Ardea insignis* in Myanmar.

Date	Number	Locality	Source
23 January 2018	1 immature	Near Myitkynia	This paper
26 March 2018	1 immature	Near Myitkynia	Nyein Chan, pers. comm.
April and June 2015	1	Near Hkakaborazi National Park	Than Zaw (Stanley Price & Goodman 2015)
2013	1	Near Bhamo	Stanley Price & Goodman (2015)
2009	3	Mali Hka tributary, near Lasa (upper reaches)	BANCA (2009)
2009–2011	16	Hukaung Valley Wildlife Sanctuary (HVWS), Upper Chindwin valley	Stanley Price & Goodman (2015)
2009–2011	2	Putao Plain	Thet Zaw Naing, <i>in litt.</i> (2017)
2003 & 2005	1	Nat Kaung River, near Warazup, Kachin	Tordoff <i>et al.</i> 2007
2000 & 2001	1	Nam Sam Chaung	van der Ven (2000, 2001a)
1999	4	Putao Plain	King <i>et al.</i> (2001)
1998	4	Putao Plain	King <i>et al.</i> (2001)
1939		Near Bhamo	Stanford & Ticehurst (1938–1939)
1935		Putao Plain	Stanford (1935), Stanford & Ticehurst (1938–1939)



CHRISTOPH ZÖCKLER

Plate 13. Bird-trapping in section IV of the Ayeyarwady River, near the nesting Black-bellied Terns, 8 February 2019.

In 2019, on 5 February, a full clutch of three eggs was found in the Bhamo area (Plate 4). A mist-net nearby (Plate 13) was immediately dismantled and a fisherman camping on the sandbank was requested by the Fishery Department to move on. The Fishery Department officer accompanying the survey, Toe Tun, contacted key villagers with fishing rights, requesting them to guard the nesting pair, but in early March 2019 the nest was destroyed by a freak spring flood. An immature bird observed further south near Takaung the following day was the only additional record of this species. These records bear testament to a strong decline from 81 birds still present in January–February in the early 2000s, of which 65 birds were present in section I alone in 2000, and 69 in 2003 (van der Ven 2000, 2003, van der Ven & Thet Naw Zaing 2007).

River Lapwing *Vanellus duvaucelii* (Near Threatened [NT])

River Lapwing was observed in small numbers at only six locations in sections I, IV and VII (Figure 1). Davies *et al.* (2004) mentioned the River Lapwing as widespread across the Ayeyarwady River (Table 3) and also mentioned observations along the Mogaung Chaung tributary and at several lakes, such as Oat Ma In, the Tapain Chaung Oxbow and Wa Shaung Dam. Our sparse recent records may indicate a concerning decrease, and while a range shift to the south seems possible (Davies *et al.* 2004; Naing Lin, pers. comm.), no data are available to support this.

Waterbirds of the Ayeyarwady River

Accounts are given below for some of the common and characteristic waterbird species for which there are data from both 2017–2019 and earlier surveys. The Myitkyina–Sinbo section (section I) of the Ayeyarwady deserves special attention, not only because of its different riverine structure, but also because of a number of observed decreases in waterbird counts between the early 2000s and 2017–2019. Figure 2 shows the numbers of 13 species counted in section I in several years between 2000 and 2019, including trend lines estimated using multiple regression. Our results suggest a loss of species and a decline in numbers of some of those remaining. Black-necked Stork *Ephippiorhynchus asiaticus*, Spot-billed

Pelican *Pelecanus philippensis*, Cotton Pygmy Goose *Nettapus coromandelianus*, Great *Esacus recurvirostris* and Indian *Burbinus indicus* Thick-knees and Long-billed Plover *Charadrius placidus* were not observed in any of the 2017–2019 survey years, but all were reported regularly in the early 2000s (van der Ven 2000, 2001a,b, 2004, Davies *et al.* 2004). Some of these species, especially Indian and Great Thick-knees, are easily overlooked, but their complete recent absence and a lack of records from other observers along other river sections (Nyein Chan and Kyaw Soe Moe, *in litt.* 2020) over three seasons suggest at least some genuine declines since the earlier surveys. River section I fulfils Ramsar criterion 2 for at least four Globally Threatened species (Table 1), although three of these were recorded in only one year. For Little Pratincole, this section supports a critical life cycle stage (criterion 4) and four species surpass the 1% flyway population threshold (criterion 6). Table 1 summarises the Ramsar criteria for all qualifying waterbird species and the Irrawaddy Dolphin *Orcaella brevirostris* for all seven river sections.

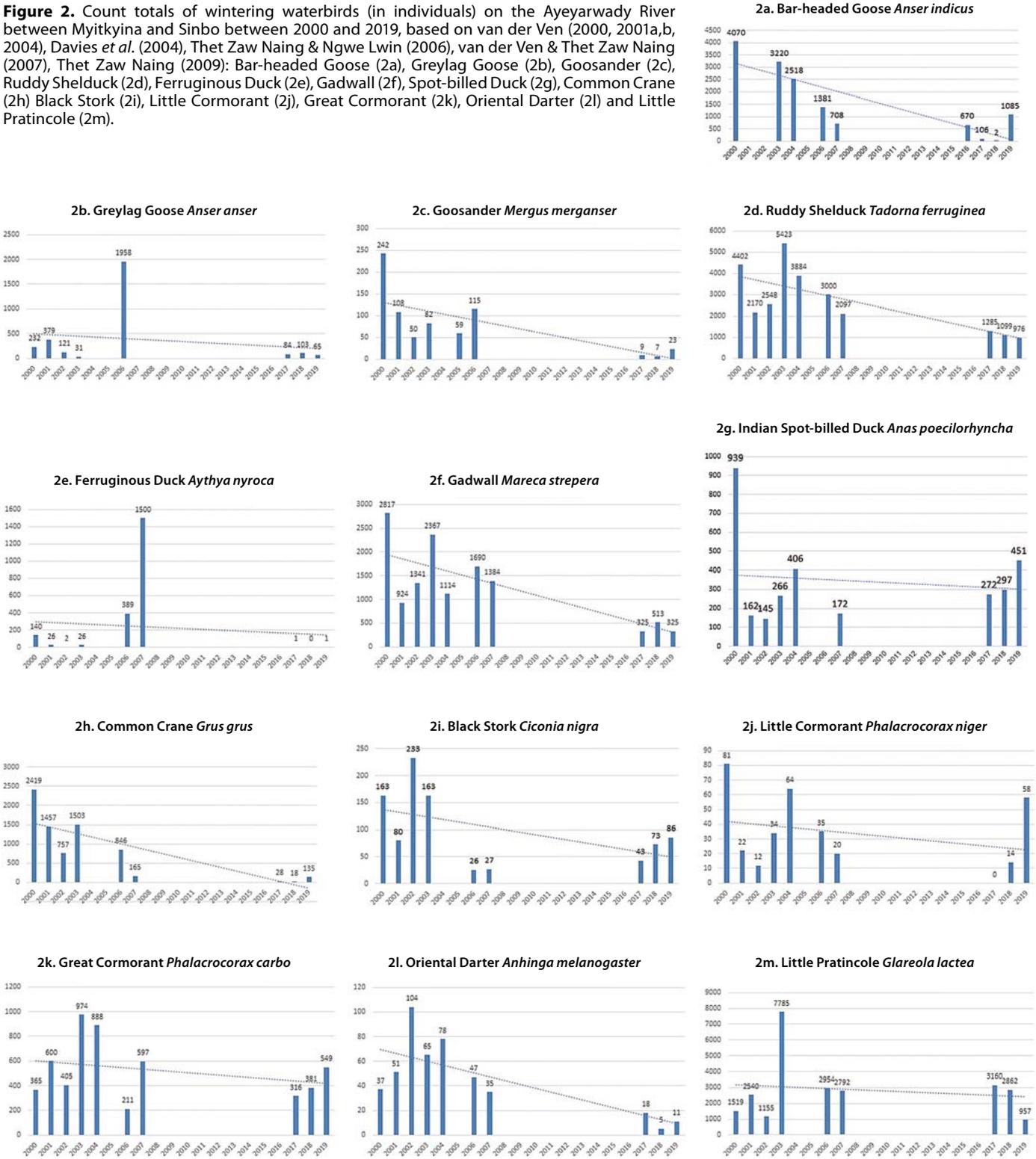
Ruddy Shelduck *Tadorna ferruginea*

Ruddy Shelduck (Plate 5) was the most numerous waterbird species encountered (Table 2). Birds migrate from the Central Asian highlands, Mongolia and north-eastern China to winter on the river. An average total of 8,116 Ruddy Shelducks was recorded in 2017–2019, representing 16% of the flyway population (Wetlands International 2012). In 2001–2003, average numbers for the entire river stretch were 8.5% higher (Davies *et al.* 2004), and the trend in count totals in section I decreased by over 75% (Figure 2). In other sections, however, e.g. III, IV and VI, the number increased, suggesting a redistribution since the earlier surveys. Each section of the river held between 2% and 5% of the flyway population, meaning that they all comfortably qualify under Ramsar criterion 6 (Table 1).

Bar-headed Goose *Anser indicus*

Bar-headed Goose (Plate 6) has shown a considerable decrease in counts (Figure 2a), which is at least partly explained by warmer winters causing more birds to stay at wintering grounds in southern China rather than crossing the main range of the Himalaya to

Figure 2. Count totals of wintering waterbirds (in individuals) on the Ayeyarwady River between Myitkyina and Sinbo between 2000 and 2019, based on van der Ven (2000, 2001a,b, 2004), Davies *et al.* (2004), Thet Zaw Naing & Ngwe Lwin (2006), van der Ven & Thet Zaw Naing (2007), Thet Zaw Naing (2009): Bar-headed Goose (2a), Greylag Goose (2b), Goosander (2c), Ruddy Shelduck (2d), Ferruginous Duck (2e), Gadwall (2f), Spot-billed Duck (2g), Common Crane (2h) Black Stork (2i), Little Cormorant (2j), Great Cormorant (2k), Oriental Darter (2l) and Little Pratincole (2m).



winter in Myanmar (Liu *et al.* 2017, Zöckler 2018). The cold 2018–2019 winter may have triggered some of the geese to return to the Ayeyarwady River.

Ducks

Indian Spot-billed Duck *Anas poecilorhyncha* (Plate 7) was one of the most frequently encountered species in 2017–2019, with an average overall count total of 3,723 (Table 2). This species was counted in the low to mid hundreds in section I every year, with a maximum of 939 in 2000, the first year with a detailed survey (Figure 2g). Gadwall *Mareca strepera* were counted in the hundreds.

Most other duck species apparently decreased between 2000–2003 and 2017–2019 (Table 2).

Common Crane *Grus grus*

Counts of this once common migrant decreased by about 90% in section I between 2000 and 2019 (Figure 2h). Relatively higher numbers were observed in other river sections, and a total across all river stretches of over 1,000 birds in 2019 (Table 2) suggests a redistribution, albeit at lower overall numbers than in the early 2000s (Davies *et al.* 2004). Over 1,500 Common Cranes were observed at Lake Indawgyi, north-west of the survey area, in

2015–2019 (unpubl. obs. by NL and CZ). It seems possible that birds which formerly wintered close to the Ayeyarwady River were at Lake Indawgyi during the surveys, and that a more widespread redistribution caused a reduction in count totals.

Van der Ven (2020) observed nearly 23,000 Common Cranes on northward migration during systematic counts from a fixed observation point near Putao between 7 and 20 March 2020. The exact wintering area of these birds is unknown, but it appears that there are still high numbers of Common Cranes wintering in Myanmar.

Black Stork *Ciconia nigra*

We recorded decreases in Black Stork counts between the two periods in section I (Figure 2i). The Ayeyarwady and Hukaung valleys (Davies *et al.* 2004) appear to be the most important wintering areas for Black Stork in Myanmar. This species rarely congregates (Plate 8), and the dispersed nature of its distribution means that the 1% Ramsar threshold was not attained.

Cormorants, darter, egrets and kingfishers

While trends for Great Cormorant *Phalacrocorax carbo* and Little Cormorant *P. niger* fluctuated from year to year (Figure 2j,k), counts of Oriental Darter *Anhinga melanogaster* were noticeably lower in the 2017–2019 period than in earlier surveys (Table 2, Figure 2l). River section III near Katha held a total of 31 Oriental Darters, which constitutes a substantial proportion of the total of 46 birds along the entire stretch in 2019.

For herons and egrets, population trends differed from species to species (Table 2). Most individuals of the high 2019 total of Cattle Egrets were recorded in the lower river sections south of Mandalay, where they congregated near the river for roosting and preening at night, but spent most of the day feeding on neighbouring agricultural land. This behaviour resulted in unpredictably variable count totals.

Among the kingfishers observed along the river, Pied Kingfisher *Ceryle rudis* (Plate 9) was the most common and widespread species.

Waders

In total, 26 wintering wader species were recorded during the 2017–2019 surveys, of which nine were observed in numbers over 100 (Table 2). The relatively high number of Dunlin *Calidris alpina* along the river was notable. This is in striking contrast to the coastal region, where the species is absent and only Curlew Sandpipers *C. ferruginea* are recorded (Zöckler *et al.* 2014), a species which was not observed among the riverine waders. It is assumed that the Dunlins are a part of the populations regularly wintering in southern China and Vietnam.

Little Pratincole *Glareola lactea*

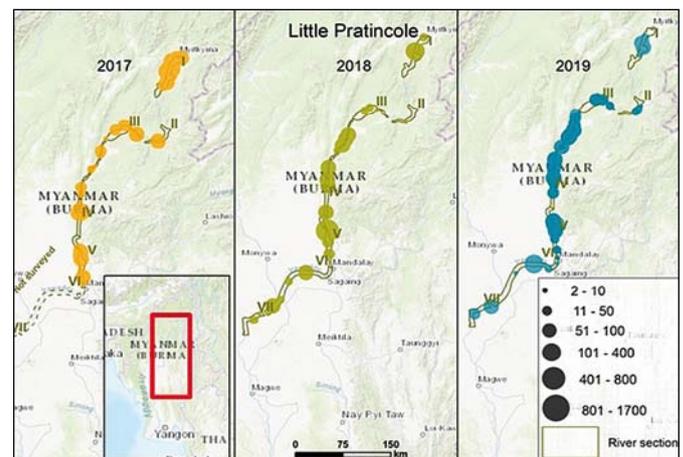
Only Ruddy Shelduck and Cattle Egret were counted in higher numbers than Little Pratincole (Table 2, Plate 10). We mapped the distribution of colonies for each year (Figure 3) and noted apparent decreases in section I (Figure 2) and II, and a possible current absence in large parts of section III. The largest colony consisted of around 1,700 birds in 2018 near Singhu in section V.

The total of 7,200 counted in 2018 represents around 8–10% of the flyway population and indicates the immense importance of this river for this species in the breeding season, when it fulfils multiple Ramsar criteria. Six out of seven of the river sections qualify as Ramsar sites for this species under Criterion 6 (Table 1), with only section II not qualifying.

Birds of prey

Of a total of 25 species of birds of prey recorded, Black Kite *Milvus migrans* was the most numerous, with more than 100 individuals present in 2019. Osprey *Pandion haliaetus* was also conspicuous. Other notable records of raptors included one Himalayan Vulture

Figure 3. Distribution of Little Pratincole *Glareola lactea* colonies along the Ayeyarwady River across all survey years.



Gyps himalayensis on 3 February 2019 soaring high above the village of Talawgyi, the only vulture observation in recent years. In both 2018 and 2019 one Long-legged Buzzard *Buteo rufinus* was present at U Laut in section I (Plate 11).

Little is known about the status of Merlin *Falco columbarius* (Plate 12) in Myanmar. It was previously only recorded on 26 March 2016 (Thet Zaw Naing *et al.* 2020). However, during our surveys we found this species four times in total, twice in 2018 in section III and once each in sections I and IV in 2019. Merlins appear to winter in the Ayeyarwady River area and to benefit from the large number of wintering passerines, particularly wagtails and hirundines.

Notable wetland-associated passerines

Large numbers of hirundines were recorded along the river in nearly all sections. The density reached a minimum of 2,000 individuals per river km, which could mean a total of at least 200,000 to a maximum of 500,000 swallows and martins regularly wintering along the river. These are rough estimates, however, and a more focused survey of sample stretches is recommended to improve accuracy. Even though the majority of swallows were Barn Swallows *Hirundo rustica*, a proportion of 15–20% Red-rumped Swallows *Cecropis daurica* was noted among the flocks, mostly in sections III–VI. Plain Martins *Riparia paludicola* and Sand Martins *Riparia riparia* were also present in high numbers, but were much scarcer than the swallows.

Large congregations of over 1,000 wagtails were observed roosting in extensive reedbeds in section I. The flocks were of mixed species, with Eastern Yellow Wagtail *Motacilla tschutschensis* dominating in section I and White Wagtail *M. alba* more common at other roost sites. While Citrine Wagtail *M. citreola* is common at nearby Lake Indawgyi, it rarely featured along the river. Pipit species included wintering Richard's *Anthus richardi* and Red-throated *A. cervinus* but also Rosy Pipit *A. roseatus*, which was regularly encountered as far south as section IV.

DISCUSSION

Summary of key findings

The surveys in 2017, 2018 and 2019 provided valuable insights into the bird community along the Ayeyarwady River and useful comparisons with earlier surveys. The count totals and the presence of multiple Globally Threatened species and species at critical life-cycle stages qualified seven stretches of the river as Wetlands of International Importance under the Ramsar Convention. Designation as such, and protection and monitoring of species dependent on these sites, should be a high priority for the government of Myanmar.

The trends and responses of waterbird species to various threats and pressures are likely to reflect changes in the river ecology. This is true for common species such as Ruddy Shelduck, Gadwall and Little Pratincole, as well as for Globally Threatened species such as Black-bellied Tern and River Tern. While in the early 2000s the main Little Pratincole population was observed in river section I, it appears that a redistribution from northern areas to less disturbed areas to the south might explain the apparent decreases in numbers in section I. This is also the section most threatened by gold panning and washing, which affects almost all of the beaches along this stretch, and poses severe threats to Little Pratincole and other ground-nesting species. The few remaining undisturbed breeding colonies need to be safeguarded from future gold and sand mining activities. It is vital for the wellbeing of this species to protect and monitor all colonies with more than 100 birds.

The population status of Black-bellied and River Terns, together with other river sandbar-nesting species such as Indian Skimmer, Great Thick-Knee and River Lapwing, appears to have deteriorated across several Asian rivers and inland wetlands (Inskipp *et al.* 2016, Claassen *et al.* 2017, Chowdhury *et al.* 2014, Debata *et al.* 2019, Mittermeier *et al.* 2019). These decreases in population status require urgent attention by the global conservation community and in some cases possibly further assessment and uplisting of their Globally Threatened status.

The Indian Spot-billed Duck showed a possible increase compared to the 2000–2003 surveys (Davies *et al.* 2004). If there has indeed been an increase in numbers present rather than just in numbers counted, this might be regarded as a welcome development, but it could also mean that the riverine wetlands might be a refuge for birds escaping the deteriorating wetlands in the wider river basin, a process similar to the buffer effect (Gill *et al.* 2001). Some species such as Black Stork, Common Crane and Oriental Darter, as well as many waders, showed substantially higher counts in 2019 than in 2017 and 2018, but these increases are more likely to reflect the higher water levels in 2019, or other reasons, rather than genuine changes in numbers. Even if there have been real changes in numbers, it remains to be seen in future surveys if this trend holds. Long-term climate change and differences in weather conditions between years could also impact the migratory behaviour of some species, as seen in the example of the Bar-headed Goose (Liu *et al.* 2017, Zöckler 2018).

Great care was taken in the design of our study to ensure that the methodology was appropriate and reasonably accurate for comparisons between years, despite difficulties with standardising counts on a river of this width and channel complexity. The success of the standardisation of methodology between years was confirmed by congregations of certain species often being recorded by the different surveys at the same places on the river. There will always be errors in counts over such a large area, but by standardising the counting methodology, including the experience of observers, type of boat used and duration and timing of the counts each year, comparisons with future monitoring will be possible. Some species, such as Northern Pintail and Common Teal *Anas crecca*, showed differences in counts between years where oversight in one year might be a more likely explanation than a decline or increase in actual numbers. Despite such apparent inter-annual changes, comparisons with previous periods in the early 2000s are possible and suggest decreases in numbers of many species wintering on the Ayeyarwady River. The disappearance of several species such as Spot-billed Pelican (222 in 2000 (van der Ven 2000)), Black-necked Stork (7 in 2001 (Davies *et al.* 2004)) and possibly Great Thick-knee all add to the overall picture of likely declines in riverine waterbirds.

Threats to the riverine wetlands and their waterbirds

Waterway modification and damming

The Ayeyarwady River is one of very few large rivers in the world that has not been dammed, aligned or interrupted by permanent

man-made structures. This has ensured an unhampered flow of water, sediments and nutrients, resulting in a relatively unspoiled wetland ecosystem that is home to dolphins, many fish and waterbird species. However, a few river sections have been altered over the past 20 years. Small ponds and old river channels have been infilled and the river's course straightened at two or three locations in sections I and II. The riverine ecosystem and associated wetlands provide the basis for livelihoods in many human communities that live nearby. Any major development for such purposes as generating electricity or creating large irrigation schemes will disrupt this delicately balanced system with serious consequences not only for fish and waterbird populations but also for local communities. The Myitsone Hydropower Project, still under moratorium by the current Myanmar government, which aims to build seven dams at the confluence and along the two tributaries that form the Ayeyarwady, is a drastic threat to its riverine ecosystem, hydrology and to fish migration routes (International Rivers 2013). An equally serious potential threat is the proposed 'China–Myanmar Ayeyarwady Economic Belt' project as part of China's Belt and Road Initiative, combining the construction of rail and road links from Yunnan to Bhamo, including the channelisation of the Ayeyarwady River from Bhamo to the Indian Ocean, to facilitate transport by cargo ships (Belt and Road News 2020).

Agricultural expansion and irrigation

An increasing human population expanding along the river is demanding ever more agricultural land. Maize and peanut fields, as well as beans and other crops, are expanding into reed and grassland areas, causing increased pollution by agricultural and domestic discharge and residues. Sandy islands and riverbanks are being encroached upon by fishermen and cattle herders, who modify the characteristic reedbed and grass vegetation, reducing habitats of many reedbed species such as Jerdon's Bushchat *Saxicola jerdoni* and Striated Babbler *Turdoides earlii*.

Hunting

Hunting and poaching are systemic, widespread and illegal, and were observed in almost all river stretches. Bait poisoning has also been recorded. There is, however, little or no law enforcement by relevant government departments. Van der Ven (2001a,b, 2004) already noted high levels of hunting along the river.

During the 2019 survey we were accompanied by staff from the Fishery Department, who were instrumental in enforcing the hunting ban on birds. In total, three nets were removed, but many more were encountered when surveying without government representatives on board. A large-scale awareness campaign involving village leaders is needed to combat the systemic hunting and trapping of migratory waterbirds along the river. This approach has been successfully applied in the awareness raising and hunting control in the Spoon-billed Sandpiper *Calidris pygmaea* conservation project in Myanmar (Pyae Phy Aung 2016).

Gold panning and sand mining

The most obvious human impact on the river is the increasing conversion of the gravel banks into gold dredging areas. Semi-industrial gold-washing installations and also small-scale artisanal operations were observed on several river stretches, regularly turning over the top layer of the river sediments and leaving small gravel pyramids behind. Some birds such as Little Pratincole still continued to breed among these piles of pebbles, but were clearly affected and reduced in numbers. Some gravel banks near military installations, for example, were less affected and had higher numbers of Little Pratincoles, possibly also due to lack of other human disturbance. Other sections were less affected by gold panning and dredging, and seemed to have maintained or even increased their numbers of breeding Little Pratincoles. The disturbance created by these mining and dredging activities may have contributed to

decreasing numbers of additional ground-nesting birds, including the disappearance of River Terns.

Protected area planning

Ramsar site designation

Each river section fulfils at least two Ramsar criteria and supports a large and important number of waterbirds (Table 1). Each of the seven sections thus qualifies as a Wetland of International Importance under the Ramsar Convention. The sections correspond with natural boundaries, separated by gorges or other geographical or man-made markers such as the bridge between sections V and VI. Since all sections are connected by the same river, it would make sense to designate all of them as one cluster of Ayeyarwady River Ramsar sites.

Ramsar criterion 1 applies to all river sections as they have all maintained their original river character, with minimal man-made modification. Agricultural intrusion, often accompanied by hunting, has been widely noted, but these activities are only intermittent and seasonal due to the annual river dynamics. Only sections VI and VII combined attained the 20,000 individual waterbirds required by criterion 5, but all sections together surpassed 30,000 (2017, 2018) and even 40,000 waterbirds in 2019.

Community Conservation Areas and Fish Conservation Zones

The national, regional and state fisheries laws provide a legal framework for designating Fish Conservation Zones, which are strict no-take zones. FFI and the Fisheries Department of Kachin State facilitated the designation of community-managed fish conservation zones on the Mali Hka, an upper tributary of the Ayeyarwady, for the protection of fish aggregation areas and fish spawning areas. The upper Ayeyarwady River section between Mandalay and Myitkyina would benefit from an extension of this approach. Seasonally flooded grasslands are important for the protection of fish spawning sites as well as for waterbird conservation. The Myanmar Fisheries Department designated an Irrawaddy Dolphin Conservation Area in 2005, initially spanning 74 km of the Ayeyarwady River, with a further expansion into a 100 km stretch of the river in 2018 between Mandalay and Shwegu in sections II, III and IV. Effective conservation measures are, however, limited to dolphin protection and fishing gear restrictions (Mongabay News 2018).

Several key nesting areas, especially all sites still used by riverine terns and other ground-nesting species, would benefit from the legally binding designation of Community Conservation Areas (CCAs) under Myanmar's 'Conservation of Biodiversity and Protected Areas Law no 12/ 2018' to protect these sites from endangerment by accidental or deliberate intrusion and disturbance. CCAs could be developed based on lessons learned from successful nest protection schemes for Black-bellied Tern nesting sites (WCS 2018). Species that would also benefit from this intervention include the Globally Near-Threatened River Lapwing and Great Thick-knee. The latter has undergone precipitous declines in South-East Asia in the twenty-first century (BirdLife International 2020). Specially designated areas would need to be negotiated and jointly delineated with local communities. These sites should focus on the core nesting sites of the few remaining riverine terns (three sites, Figure 1). Key interventions should focus on the prevention of agricultural encroachment and nest predation, but similar schemes on the Mekong River demonstrated a much more complex set of issues (Claassen *et al.* 2017) that cannot be applied to the Ayeyarwady River due to multiple cultural and developmental differences.

UNESCO Biosphere Reserves

Together with Ramsar sites as core areas and the adjacent forest and agricultural land, the general area is highly suitable for protection and management as a UNESCO Biosphere Reserve. This designation has the aim of promoting sustainable development across wide landscapes, defining core areas for stricter protection and promoting

buffer and development zones. Especially in combination with Community Conservation Areas (CCAs) and Ramsar sites, there is potential for the whole river system to receive the level of protection and co-management necessary to escape a vicious cycle of ecological and social damage. The Biosphere Reserve framework would provide a unique opportunity for local stakeholders to integrate conservation and sustainable development, and for local communities to develop models for the wise use of wetlands.

Mainstreaming wetland conservation into basin-wide planning processes

Protected area designation is not sufficient by itself to guarantee protection of ecological integrity. It is critical to integrate the findings of this research into regional and basin-wide land-use and development plans, for which the World Bank's Ayeyarwady Integrated River Basin Management Project can provide a framework. Creation of protected areas and designation under international conservation instruments provide a vital framework, but implementation of activities leading to conservation action and sustainable development on the ground are essential if these instruments are to succeed.

The implementation of an awareness programme for the entire river stretch is highly recommended to tackle bird hunting and habitat conversion, but also to launch a 'Living Ayeyarwady' campaign.

Future monitoring

Overall, the surveys required about 12 days per year to cover all river sections. A more intensive and complete baseline survey over a longer time period would be valuable to establish the proportion of each species likely to have been missed by earlier surveys, and to discover the extent to which diminishing returns apply to increased effort. But more frequent monitoring is also required, and for this, effort needs to focus on the most important stretches of the river. In light of the difficulties with research permits and areas of insurgencies, it might be worth considering a reduction of survey areas to only the northern half of section I and also only part of section III downstream from Shwegu, and to omit sections II and VII. This would expedite surveys and still result in coverage of the most important river stretches.

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