Technical Report: **Shoebill survey in Bangweulu Swamps, Zambia** under the **Wetlands International '"AEWA/BUWAL IWC 2006 "**

Lizanne Roxburgh[1&3], Bob Stjernstedt[1], Daniel Mwizabi[2] and Klaus Droppelmann[1&4]

1. Zambian Ornithological Society, P.O. Box 33944, Lusaka, Zambia
2. Zambia Wildlife Authority, Private Bag 1, Kafue Road, Chilanga, Zambia
3. Percy Fitzpatrick Institute of African Ornithology, University of Cape Town, Private Bag X3, Rondebosch, 7701 South Africa
4. Private Bag 16, Woodlands, Lusaka, Zambia

Summary

We conducted an aerial survey of shoebills in the Bangweulu Swamps, Zambia using a microlight aircraft. The survey was conducted from the 22nd to 24th July 2006. We flew 488 km, 8 hours, in an area of 1800 km^2. We saw 20 shoebills in our aerial transects, and found two nests, one of which contained a single chick. Our estimate for the population size for our survey area is between 240 and 530 shoebills. However, our survey area did not cover all suitable shoebill habitat and total population size could be between 500 and 1000 birds.

We also conducted a general waterbird count within the vicinity of Chikuni Island, by foot, boat and car. Wattled cranes and spur-winged geese were also counted from the air, as these were easy to identify. In total, 4614 birds of 51 species were seen, including an additional 5 shoebills in areas not covered by the aerial survey.

In informal interviews with fishermen and ZAWA staff at Chikuni Island, allegedly shoebill eggs and chicks are being collected, both for consumption by fishermen and possibly for sale, most likely to zoos or to collectors. In addition, there is no control of fishing methods and destructive methods, such as fishing with mosquito netting and shade cloth and use of poison, are being employed.

For future surveys and estimates of the population size of shoebills, we recommend that a more conservative strip width be used. We found that shoebills were difficult to locate beyond a distance of about 200 m from the plane. In addition, the full extent of shoebill habitat is unknown. We plan to assess this using satellite imagery. Shoebill movements between wetlands within Zambia and within the region are unknown, as are the impacts of fishing and increasing disturbance by a growing human population on the shoebill population.

Introduction

A survey of shoebills (*Balaeniceps rex*) was conducted in 2006 in the Bangweulu Swamps, Zambia, from the 19th to the 26th July. Shoebills' 2006 IUCN Red List Category is Vulnerable (BirdLife International 2006a), because, although this species is widespread, it is also rare. It is estimated to have a single small population in Africa, with individuals ranging widely within its broad extent of occurrence. The global population is undergoing a continuing decline due to hunting, nesting disturbance and burning of its habitat.

Shoebills occur from the southern Sudan to northern Zambia. They frequent large freshwater swamps overgrown with reeds, papyrus and grass (Brown *et al.* 1982). They feed mostly on lungfish and catfish, but also other types of fish and aquatic animals such as frogs, turtles and aquatic snakes. They breed in Zambia when the flood waters begin to recede, from about April to July (Brown *et al.* 1982). Collection of shoebill chicks is known from the Bangweulu Swamps (Kamweneshe *et al.* 2003) and their CITES status is currently under review. Current estimates for the global population are between 5000 and 8000 birds, most of which are in the Sudan (Dodman 2002), with populations in several countries under severe threat.

The Zambian sub-population in the Bangweulu Swamps is thought to number less than 500 individuals. Although individuals are occasionally reported further south, the Bangweulu Swamps is the main stronghold of shoebills in Zambia. The population size has been estimated in two previous aerial surveys, in 1983 (Howard & Aspinwall 1984) and in 2002 (Kamweneshe *et al.* 2003). Both surveys estimated that the population was between 200 and 300 birds. However, these surveys focused on black lechwe (*Kobus leche smithemani*) and wattled cranes (*Bugeranus carunculatus*) respectively, both of which often occur in large herds or flocks, and, by and large, do not occupy the same habitat as shoebills. In addition, during the African Waterbird Census in July 1993, 25 shoebills were seen from the air and 14 from the ground, and this was estimated to represent 35 birds. Population size was not estimated.

The Bangweulu Swamps is a vast area of lakes, swamps, floodplains and termitaria savanna in the north-east of Zambia. The area holds considerable numbers of large mammals and is popular for both ecotourism and trophy hunting. It is an Important Bird Area (IBA ZM026) and also a Ramsar site. Although much of the site, at least the southern half, falls within protected areas (game management areas), in practice it receives very little protection (Leonard 2005). The area supports quite a large human population, with many permanent settlements on islands and on the edges of the floodplain. There are also temporary fishing camps deeper within the swamps, and fishing pressure within the swamps is likely to be high, as most communities are to a large extent dependent on fishing.

Our aim was to conduct a shoebill-focused aerial survey of the Bangweulu Swamps, and to provide recommendations for future more extensive aerial surveys of shoebills. Additionally we counted all wattled cranes from the air, and noted species of other large birds that we could identify as well as Sitatunga antelopes. A ground team counted other waterbirds in the vicinity of Shoebill Island Camp, and also conducted informal interviews with fishermen.

Methods

1) Aerial Survey of Shoebills

a) Technical details

We conducted the aerial survey using a microlight aircraft. We obtained permission from the Zambia Wildlife Authority and from the Department of Civil Aviation to conduct the survey. We disassembled the microlight in Lusaka, placed it on a trailer and towed it by road to Kasanka National Park. Here we reassembled the microlight and flew it from Mulembo Airstrip in Kasanka National Park (12°32'S 30°18'E) to Chikuni Airstrip (11°58'S 30°15'E) on the southern edge of the Bangweulu Swamps. Petrol for the microlight and supplies for the team were ferried to Chikuni with the vehicle.

Technical details of the survey are given in Table 1. We flew transects at a height of 300ft (approx. 100m) above ground. In total we flew approximately 488 km

along and between transects. Transects were flown north to south because the prevailing wind direction is easterly. This allowed for a more consistent flying speed among transects. Details of transects that were flown are given in Table 2. All legs were surveyed, except for 80 km that were flown repeatedly to or from Chikuni airstrip to reach a transect waypoint, i.e., 408 km were surveyed.

Table 1. Technical details of survey

Dates of survey	22nd to 24th July 2006
Aircraft type	Microlight Solowings Aquilla 582
Total flying time	8 hours
Total distance flown	488 km*
Average speed	70 km/hour (equivalent to 45 mph)
Average height	100 m
Pilot	Klaus Droppelmann
Observer	Lizanne Roxburgh
Orientation of transects	North-south

* Note: actual distance flown was greater due to verification loops. Therefore speed multiplied by time does not equal distance

The microlight was flown to Chikuni on the morning of the 21st July, and was flown out on the evening of the 24th July. One familiarization flight plus five two-three hour survey sessions were planned. However, due to a broken spring on the exhaust, the number of survey sessions was reduced to four, as one survey session was spent replacing the spring. We flew between approximately 06h30 and 09h00 and between 15h30 and 18h00 every day. Between about 10h00 and 15h00 winds were too strong and turbulence was too great to fly safely and conveniently for surveying. However, pilot and observer fatigue would not have made additional flying time recommendable even if conditions were wind-still or non-turbulent. Time between flying sessions was used for refuelling the plane, doing safety checks, and preparing for the next survey session.

While flying transects, we recorded the coordinates of each shoebill sighting on

a handheld GPS. We assigned each sighting to a distance class from the transect centre line, i.e., 0-70 m, 70-140 m, 140 to 210 m and more than 210 m, based on the angle from the observer to the sighting. These distance classes corresponded to the following sighting angle classes: <35°, 35°-55°, 55°-65°, >65°. The sighting angle of 35° was measured as that angle to the edge of the microlight wheel covers from the observer.

b) Calculation of Shoebill population size in the survey area

No shoebills were observed at more than 200 m from the plane. The number of shoebill observations declined sharply with distance from the plane (Figure 2). We therefore assumed that all shoebills were seen in the first distance class (i.e. 0-70 m). We then assumed that our our effective strip width was 140 m (i.e. 70 m on either side of the plane). We then multiplied our strip width (140 m) by the distance flown in transects (408 km – note that this value is less than in Table 2, as there was some overlap in routes flown, and these areas were not surveyed twice) to get the area surveyed. Finally we extrapolated the number of sightings within our effective strip width by the survey area. The survey area was 40 x 45 km (1800 km^2).

It is possible that we under- or overestimated the distance to a shoebill sighting. It is also possible that we did not see all shoebills along the transects. We have therefore also included additional calculations of population size, based on changes in two parameters: 1) the effective strip width and 2) proportion of shoebills seen. If we underestimated effective strip width then the population estimate should be lower. If we did not see all shoebills in our strip then our population estimates are too low. We also analyzed the data using the programme Distance Ver. 5.0 (Thomas et al. 2005).

2) General Waterbird Count

In addition to the aerial survey, Bob Sternstedt and Daniel Mwizabi counted waterbirds in the vicinity of Shoebill Island Camp (11°57'S 30°14'E) and Chikuni, by driving along the water's edge and also walking deeper into the swamps. They also conducted informal interviews with villagers in the vicinity of Chikuni on their fishing methods and their knowledge of shoebills.

Table 2. Transects flown in the Bangweulu Swamps, Zambia. Coordinates (south and east) are given in decimal degrees.

Date	Time	Waypoint	South	East	Distance flown (mi)	Distance flown (km)
22.07.2006	Pm	Chikuni Airstrip	11.967	30.254		
		T1	11.967	30.083		
		T2	11.633	30.083		
		T3	11.633	30.100		
		T4	11.967	30.100		
		T5	11.967	30.117		
		T6	11.800	30.117		
		T7	11.800	30.133		
		Chikuni Airstrip	11.967	30.254	85 mi	136 km
23.07.2006	Am	Chikuni Airstrip	11.967	30.254		
		T8	11.967	30.133		
		T9	11.600	30.133		
		T10	11.600	30.167		
		T11	11.867	30.167		
		T12	11.867	30.183		
		T13	11.750	30.183		
		T14	11.750	30.200		
		Chikuni Airstrip	11.967	30.254	72 mi	116 km
23.07.2006	Pm	Chikuni Airstrip	11.967	30.254		
		T22	11.967	30.000		
		T21	11.800	30.000		
		T20	11.800	30.017		
		T19	11.967	30.017		
		T18	11.967	30.033		
		T17	11.800	30.033		
		T16	11.800	30.050		
		T15	11.967	30.050		
		Chikuni Airstrip	11.967	30.254	78 mi	125 km
24.07.2006	Am	Chikuni Airstrip	11.967	30.254		
		T23	11.833	30.233		
		T24	11.667	30.233		
		T25	11.667	30.267		
		T26	11.833	30.267		
		T27	11.833	30.300		
		T28	11.667	30.300		
		T29	11.667	30.333		
		T30	11.933	30.333		
		Chikuni Airstrip	11.967	30.2542	69 mi	111 km
Total Distance flown					**304 mi**	**488 km**

Results

1) Aerial Survey of Shoebills

We saw 20 shoebills altogether. Each sighting was confirmed by circling the sighted bird or birds. We also saw two active nests. One nest had a chick in it. An adult bird was sitting on the second nest and we were therefore unable to identify the contents. Figure 1 shows our flight paths and all shoebill sightings and the location of the 2 nests seen in the aerial survey plus a third nest that was found in an area much frequented by guides from Shoebill Island Camp, and hence not covered by this survey.

Figure 2 shows a sharp decline in the number of shoebill sightings with distance from the centre line of a transect. We did not see any shoebills at a distance of more than 210 m. Estimates of population size need to be corrected for this decline in sightings, or if using strip transects, then the width of these should be relatively narrow. Note that although there were 12 sightings in the 0-70m distance class, 3 of these were pairs and thus 15 birds were seen.

Our population estimates are based on the assumption that all shoebills were seen within 70 m of the plane. We saw 15 shoebills within 70 m of the transect line. Conversely, we could also say that we should have seen 45 shoebills within 210 m of the plane, rather than just 20. Our survey extended over an area of 1800 km^2, and we thus estimate that the population of shoebills within this area is 470 (Table 3).

As a caveat, Table 4 and 5 show the effects of either underestimating the sighting angle/ distance and thus the effective strip width, or of having seen less than 100% of shoebills within the effective strip width. Of those errors that are most likely, we can say that our population of shoebills for the surveyed area alone should lie between 240 and 530 birds.

The estimated number of shoebills using the programme Distance V. 5.0 are as follows: 533, lower confidence limit = 258, upper confidence limit = 1100. This is slightly higher than our estimate, but our estimate falls within the confidence limits of the Distance estimate.

Figure 1. Location of flight paths and shoebill sightings on a satellite image. Green dots are shoebill sightings, red stars are nest locations, coloured lines are transects flown on different days and times.

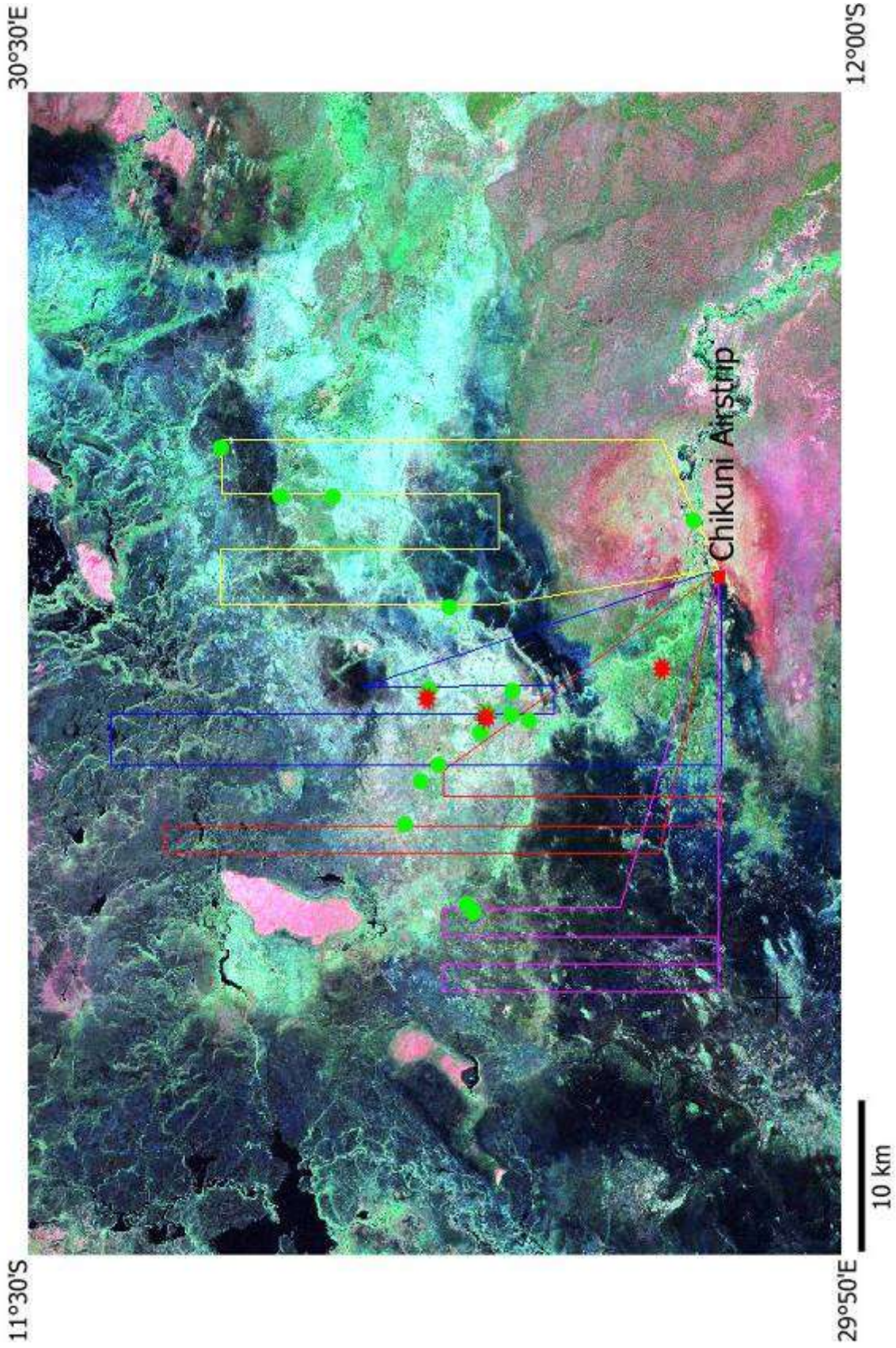

Figure 2. Decline in number of sightings of shoebills with average distance from the centre of the transect**.**

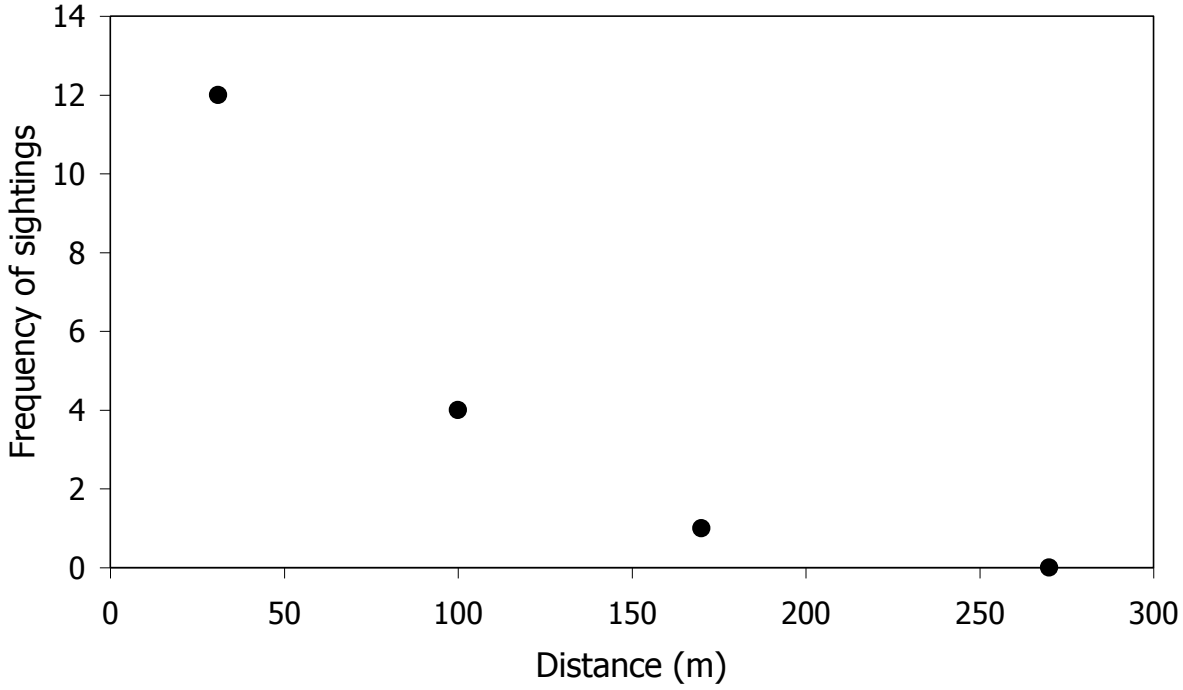

Table 3. Data used for estimating population size of Shoebills in the survey area within the Bangweulu Swamps

Observed number of shoebills	20 (15 within 70 m of the plane)
Effective strip width	140 m
Size of survey area	1800 km^2
Distance flown for sampling	408 km
% coverage of survey area	3 %
Population estimate for survey area	470

Table 4. Alternate estimates of population size of shoebills, assuming that distance to shoebill sightings was underestimated. Number of shoebills counted in first distance class (i.e. distance within which all shoebills are seen) is 15. Values that are given in **bold type** are those that are most likely.

Distance within which all shoebills are seen (km)	Strip width (km)	Size of sampled area (km^2)	Proportion of area coverage	Population estimate
0.035	0.05	20	0.011	950
0.07	0.1	41	0.023	**470**
0.14	0.2	82	0.045	**240**
0.21	0.5	204	0.113	160
0.42	1	408	0.227	80

Table 5. Alternate estimates of population size, assuming that 100% or less of all shoebills were seen. Values that are in **bold type** are the most likely.

Distance within which all shoebills are seen (km)	Strip width (km)	Size of sampled area (km^2)	Proportion of area coverage	Population estimate	%
0.07	0.14	57	0.032	**470**	**100**
0.07	0.14	57	0.032	**530**	**90**
0.07	0.14	57	0.032	590	80
0.07	0.14	57	0.032	690	70
0.07	0.14	57	0.032	790	60
0.14	0.28	114	0.064	**240**	**100**
0.14	0.28	114	0.064	**260**	**90**
0.14	0.28	114	0.064	300	80
0.14	0.28	114	0.064	340	70
0.14	0.28	114	0.064	390	60

Table 6. Population estimates from previous surveys

Number of shoebills seen	**Estimated number of shoebills**	**Date of survey**	**Reference**
33	232	7^{th} to 9^{th} Oct. 1983	Howard & Aspinwall 1984
51	200	9^{th} to 11^{th} July 2002	Kamweneshe *et al*. 2003

2) General Waterbird Count

Waterbirds counted from the ground in the vicinity of Shoebill Island Camp and Chikuni Island are indicated in Table 7. A few species were seen from the air that were not seen on the ground, and these are indicated in Table 7 as well. In addition, we also counted 500 Spur-winged Geese and 510 Wattled Cranes from the air.

3) Information collected on fishing methods and shoebills in informal interviews

Fishing is the main economic activity of the people in the Bangweulu area. There are permanent villages located along the lengths of all mainland shores and on larger islands. Since it is impossible to have permanent villages in the swamps, fishermen migrate from the villages in the dry season and set up camps on smaller islands for fishing. The camps are made of sticks, papyrus and reeds and sometimes are set on floating masses of reeds and papyrus. Conditions are such that there is little fishing in the swamps during the wet season, from December to May, when fishermen return to their villages and most of the smaller islands become submerged.

Despite Government prohibitions and fishing regulations, there are no restrictions on what type of fishing methods can be used in the swamps. As a result all types of fishing methods are used. The main ones are weirs, seine nets, spears, baskets, poison, and baited hooks.

Problematic fishing methods are:

1 Seine netting. Instead of using 1 to 3 inches stretched mesh, shade cloth is used to haul undersize fish and other aquatic organisms.

2. Weir trapping. Instead of using the old method of weir trapping where people used traps made of sticks and poles, stones, earth and reeds, mosquito nets are now used in traps, and thus catch very small fish.

3. Poison. This is used during the dry season by crushing leaves/and or bark of different kinds of vegetation and killing fish in isolated and drying ponds.

It appears that the only time when fishing restrictions are imposed is at the end of the season when fish traders are ambushed by the Fisheries Department. However, the fishermen themselves are seldom approached.

The following information was gathered on shoebills:

1) allegedly during the breeding season some fishermen consume Shoebill chicks and eggs, and

2) tour or hunting operators have apparently been known to catch chicks for rearing and probable sale. An example was given of an operator who captured one and threatened to fire any worker who reported this matter to either ZAWA or the Police. The interviewee did not know where this bird was taken.

Table 7. Waterbirds seen in the vicinity of Shoebill Island Camp and Chikuni Island.

SPECIES	NO.	SPECIES	NO.
PELICANS		***GEESE & DUCKS***	
unidentified pelicans - *Pelecanus spp.*	4*	White-faced Whistling-Duck - *Dendrocygna viduata*	50
		Spur-winged Goose - *Plectropterus gambensis*	50+ 500§
CORMORANTS & DARTER		Knob-billed Duck - *Sarkidiornis melanotos*	200
Reed Cormorant - *Phalacrocorax africanus*	100	Egyptian Goose - *Alopochen aegyptiacus*	4
African Darter - *Anhinga rufa*	*	Yellow-billed Duck - *Anas undulate*	50
		Red-billed Teal - *Anas erythrorhyncha*	82
HERONS & EGRETS		Hottentot Teal - *Anas hottentota*	40
Grey Heron - *Ardea cinerea*	5		
Goliath Heron - *Ardea goliath*	*	***RAILS, GALLINULES & COOTS***	
Purple Heron - *Ardea purpurea*	*	Black Crake - *Amaurornis flavirostra*	40
Great White Egret - *Casmerodius albus*	20	Moorhen - *Gallinula chloropus*	2
Slaty Egret - *Egretta vinaceigula*	3	African Water Rail – *Rallus caerulescens*	4
Black Egret - *Egretta ardesiaca*	27		
Little Egret - *Egretta garzetta*	40	***FINFOOT & JACANAS***	
Cattle Egret - *Bubulcus ibis*	200	African Jacana - *Actophilornis africana*	150
Squacco Heron - *Ardeola ralloides*	100	Lesser Jacana - *Microparra capensis*	50
Green-backed Heron - *Butorides striatus*	3		
Little Bittern - *Ixobrychus minutes*	20	***STORKS***	
Black-crowned Night-heron - *Nycticorax nycticorax*	100	Yellow-billed Stork - *Mycteria ibis*	30
		African Openbill Stork - *Anastomus lamelligerus*	80
		Saddle-billed Stork - *Ephippiorhynchus senegalensis*	4

SPECIES	NO.	SPECIES	NO.
CRANES		***IBISES & SPOONBILLS***	
Wattled Crane - *Grus carunculatus*	100+510§	Sacred Ibis - *Threskiornis aethiopicus*	1200
Grey Crowned Crane - *Balearica regulorum*	1	Hadada Ibis - *Bostrychia hagedash*	5
		Glossy Ibis - *Plegadis falcinellus*	300
WADERS/SHOREBIRDS		African Spoonbill - *Platalea alba*	19
Painted Snipe - *Rostratula benghalensis*	10		
Black-winged Stilt - *Himantopus himantopus*	20	***HAMERKOP & SHOEBILL***	
Red-winged Pratincole - *Glareola pratincola*	100	Shoebill - *Balaeniceps rex*	5+ 20§
Long-toed Plover - *Vanellus crassirostris*	50		
Blacksmith Plover – *Vanellus armatus*	100	***BIRDS OF PREY***	
Wattled Plover - *Vanellus senegallus*	10	African Fish Eagle - *Haliaeetus vocifer*	*
Kittlitz's Plover - *Charadrius pecuarius*	200	African Marsh Harrier - *Circus ranivorus*	*
Three-banded Plover - *Charadrius tricollaris*	10		
Wood Sandpiper - *Tringa glareola*	1	***GULL, TERNS & SKIMMER***	
Spur winged plover - *Vanellus spinosus*	1	Grey-headed Gull - *Larus cirrocephalus*	17
Common sandpiper - *Tringa hypoleucos*	1		
		TOTAL: 4614 BIRDS of 51 **SPECIES**	

* indicates birds seen from the air, and not seen during ground surveys

§ indicates birds counted from the air

Discussion

Our estimate of the population size of shoebills in the Bangweulu Swamps is larger than those of earlier aerial surveys (Table 6). This may be due to surveying during a different season (for Howard & Aspinwall 1984) or of different estimates of how far from the plane a shoebill can be sighted (for Kamweneshe *et al*. 2003).

Kamweneshe *et al.* (2003) used the strip transect method in their survey. They assumed that all large flocks of wattled crane could be sighted within 1000 m of the centre line, i.e., a strip width of 2 km. They multiplied wattled crane sightings of singletons, pairs and small groups by 2 to get an estimate of population size, arbitrarily assuming a 50% observation rate. However, this would estimate the population size for the transects flown and not for the entire survey area since their strip transects were placed 2 nautical miles (i.e. 3.7 km) apart, and the coverage of the core survey area was 40-53%. Thus, wattled crane estimates for the transects should have been corrected for this, and population estimates should be higher. Using their own methodology, and an area coverage of 50%, should have yielded a population estimate

of 1616 wattled cranes.

For shoebills in the 2002 survey, the strip width was reduced from 1000 m on either side of the plane to 500 m on either side, i.e., a strip width of 1000 m rather than 2000 m. To calculate the population size of shoebills in the core survey area, the number of shoebill sightings was multiplied by 4. They counted 51 shoebills and their estimate for the number of shoebills in the survey area was 'at least 200'. Based on our findings, we do not think that all (or even most) shoebills can be seen within 500 m of the centre line of a strip transect. Strips widths for shoebill counts should be no more than 500 m (i.e., 250 m on either side of the centre line of a strip transect). Using the 2002 count but basing it on this strip width would have produced a population estimate of at least 400 birds. We believe that the 2002 survey underestimated the number of shoebills in the swamps. It probably underestimated the number of wattled cranes as well, as area coverage was only 50%, and this was not accounted for in the population estimates.

The 1983 survey was conducted much later in the dry season, at which time water levels would have receded significantly more than in July when our survey was conducted, and similarly shoebills may have receded further north into the swamps, or even wandered further north in Africa. However, little is known of shoebill movements within Africa, and satellite tracking of shoebill movements would be a useful exercise.

It may be argued that, due to the presence of only 1 observer in our survey rather than 4, the sighting distance was reduced. However, we saw a similar number of shoebills per length of transect flown (0.04 individuals per km for this survey vs 0.03 for the 2002 survey). The 2002 survey was designed to estimate population sizes of wattled cranes and not shoebills, and the differences in our estimates of population sizes highlight the need for a shoebill-focused survey, or at least shoebill specific assumptions, rather than counting shoebills, and estimating population sizes, as a by-product of other surveys.

Thus, we deduce that two important pieces of information are vital for

estimating the population size of shoebills in the Bangweulu Swamps: firstly, the distance from the observer at which all shoebills can be sighted, as discussed above. Or conversely, what is the decay in sightings with distance from the centre line of the transect? We observed a sharp drop off in sightings with distance and could assume that all shoebills were seen within only 70 m of the centre line of the transect. If a strip transect methodology is to be used for future surveys, the width of the transect should not be set at more than 500 m. In our experience, shoebills cannot be easily found or identified at a sighting distance of more than about 200 m. While it may be argued that the number of observers was greater in the 2002 survey, and thus that they could observe shoebills at a greater distance, they were also travelling at twice the speed than in our survey. This is likely to offset the greater number of observers.

Secondly, what is not known is the extent of suitable habitat for these birds in the swamps. From preliminary mapping of our sightings on satellite imagery it appears that suitable habitat occurs in a broad band that stretches from west to east, between about 10 and 30 km north of Chikuni Island, in our survey season. Our survey would have covered at least 50% of this habitat. If an additional area of similar size to our survey area exists that is suitable habitat, this means that the population size of shoebills is greater than our estimate of 470. Suitable habitat also appears to occur along the Lukulu River further to the east and south of Chikuni Island, and along other river courses. Satellite image analysis of our data may be possible, in order to estimate the extent of suitable habitat in the swamps and also to examine seasonal changes in extent of suitable habitat.

Conclusions

We therefore estimate that the population size of shoebills within the Bangweulu swamps is 470 birds. This may vary seasonally but we have very little knowledge of shoebill movements between different wetlands. Our estimate is larger than those of previous surveys, but we think that previous surveys underestimated the population size, rather than that there has been an increase in population size. To be able to detect a decline in population size, an accurate measure of population size is needed in the first place. We hope that this higher estimate does not encourage complacency in

the conservation of this species, as a population of 500 birds is far from secure, and needs greater protection than it currently receives. We hope that our survey will raise the profile of this species, and stress the importance of adequate protection for this species in this site. Plans were underway to convert the game management areas in the Bangweulu Swamps into a national park (Ferrar 1998), but this has never come to fruition. If this plan is not revived, then at least some form of control of fishing in the swamps is needed along with greater enforcement of a ban on collection and trade in shoebills.

In this first aerial survey of shoebills in Zambia using microlights, our experience suggests that the merits of using microlights for this type of survey can be summarized as follows:

1) cost – they are considerably cheaper to run than light aircraft or helicopters

2) visibility – this is greater than in a fixed wing light aircraft, as the observer is able to look almost directly down

3) speed – it is possible to travel at considerably lower speed than a regular fixed wing aircraft. This allows for more time to search for the target species, and to slowly circle an area to confirm a sighting if needed.

The disadvantages are that only one observer is present, and that the microlight is more sensitive to wind and thermal activity.

Recommendations for future surveys

Our recommendations for future surveys are as follows:

1) to resolve the issue of strip width or sighting distance. We recommend that a strip width of 400 m should be used. Alternatively the best strip width can be assessed by estimating the distance to each shoebill sighting using the sighting angle. The distance at which the number of sightings declines can be used as an objective estimate of strip width.

2) to use stratified sampling with the help of satellite imagery. We never saw shoebills on the open floodplains or in areas with deeper water lakes, which is entirely predictable. However, it is difficult to tell from conventional maps which areas to avoid (floodplains and lakes) and which areas to sample. Based on the

geographical location of our sightings, we hope to assess shoebill habitat using up-to-date satellite imagery and thus be able to provide this information for future surveys. Areas with a high probability of containing shoebills can therefore be sampled well.

In addition to future surveys, we also recommend that the following research would be helpful for the conservation of this species in this site:

a) knowledge of these birds' seasonal movements within the swamps in response to changes in water levels and also movements between adjacent wetlands.

b) the impact of fishing by local communities on the fish population and food availability for shoebills, and conversely, the impact of shoebill foraging on fish availability for human consumption. Is there competition for food resources?

c) the incidence of collection of eggs or chicks for consumption or sale, and of nest destruction.

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