

## Research report

### A summary report and photographic catalogue of African wild dogs in the southern Kafue ecosystem, Zambia 2007-2012



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## Abstract

A summary report and photographic catalogue of individually identified African wild dogs *Lycaon pictus* and their pack affiliations was compiled from sightings made during the period 2007-2012 in the southern Kafue ecosystem, Zambia. Ten sightings with photographs and/or videos were made first-hand by the authors while 12 additional sightings accompanied by photographs and/or videos were obtained from other sources. An additional seven verified sighting reports (lacking photographs) were included in a map of sighting distribution. A minimum of 90 African wild dogs in eight packs were documented. Mean pack size was  $X \pm SE = 8.7 \pm 1.2$  adult dogs/pack (range 4-13 adults,  $n=7$  packs). Five litters were documented; one additional litter was inferred through observations of a heavily pregnant female. This study addresses a data gap on wild dogs in the southern Kafue and may assist conservation efforts for African wild dogs now underway in the greater Kafue ecosystem and larger Kavango Zambezi Transfrontier Conservation Area.

## Introduction

Robust population estimates and trend data are key to monitoring and conserving endangered species. The African wild dog *Lycaon pictus* has been listed as an IUCN Red List Endangered species since 1990. Wild dogs are known to experience marked fluctuations in population size. Rapid die-offs and recovery coupled with long-distance dispersal movements make estimating numbers and distribution of wild dogs extremely challenging (Woodroffe and Sillero-Zubiri 2012). For these reasons, information on sub-population status, e.g. reports of sightings, pack composition, and reproductive events, contributes importantly to long-term trend data especially where focal studies are absent or intermittent.

The largest sub-populations of dogs occur in eastern (Ethiopia, Kenya, Tanzania) and southern (Botswana, eastern Namibia, western Zimbabwe, and Zambia) Africa (Woodroffe, McNutt and Mills 2004). In addition, an extensive meta-population of wild dogs has been established in fenced reserves in South Africa (Moehrenschrager and Somers 2004). The most current regional assessments give a combined estimate of 8,040 adult/yearling African wild dogs in unfenced wild areas (IUCN/SSC 2012, 2015, in press). While this appears to represent an increase from the 2012 estimate of 6,600 dogs (Woodroffe and Sillero-Zubiri 2012), the regional assessments caution that their compiled population estimates were derived from a variety of

sources that employed different methodologies some of which may contain a large margin of error.

Historically, African wild dogs were widespread throughout the woodlands and open grassland habitats of Zambia (Ansell 1960). The species still occurs sporadically throughout most of Zambia's protected areas in the east and west of the country (Sillero-Zubiri, Hoffman and Macdonald 2004) as well as on private lands and conservancies located in and adjacent to game management areas (GMAs) (White, unpublished data). The species was declared fully protected in Zambia in 1998 under the Zambia Wildlife Act No.12. There is no legal hunting of African wild dogs allowed in Zambia.

Apart from a countrywide questionnaire conducted by Buk (1995), most studies of wild dogs in Zambia have been focused mainly on national parks including the Lower Zambezi (Leigh et al. 2006), South Luangwa (Becker et al. 2013; WWF 2016), and Liuwa Plains (Droge et al. 2017). Until recently, very limited research had been conducted on wild dogs in the Kafue National Park (KNP) or adjoining GMAs that together comprise the greater Kafue ecosystem. Mitchell et al. (1965) reported on predation by wild dogs and other carnivore species in the KNP and the two adjoining GMAs of Mumbwa West and Sichifula (sic), however, neither distribution nor abundance of dogs was recorded. Buk (1995) reported "medium-to-high" sighting frequency of wild dogs from 1993-1994 throughout the greater Kafue ecosystem, with the exception of "low" frequency in Namwala GMA. No

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data were available from Bbilili GMA. In summarizing the status of African wild dogs in Zambia, Woodroffe et al. (1997) cited Buk (1995), but used their own terminology in reporting sightings of wild dogs in southern KNP (SKNP) as “frequent”, and in describing the sighting frequency as “rare” in Mumbwa and Namwala GMAs and as “common” in Mulobezi and Sichifulo GMAs. A two-year study (2003-2004) restricted to the northern KNP (NKNP) reported 9-10 wild dog packs in the NKNP (Carlson, Carlson and Bercovitch 2004), although through interviews and a single sighting in 2004, Carlson et al. (2004) estimated an additional six packs in SKNP. A subsequent status review of carnivores in the Zambezi Basin used Carlson et al.’s (2004) estimate for the Kafue (Purchase, Mateke and Purchase 2007), while noting data gaps for dogs in many parts of Zambia. We are unaware of any ground-based surveys conducted prior to ours on wild dogs throughout the SKNP and adjoining GMAs that together comprise the southern Kafue ecosystem.

The IUCN’s 2012 population estimate for the NKNP and SKNP combined was 300 African wild dogs (Woodroffe and Sillero-Zubiri 2012). However, the IUCN’s 2015 Regional Conservation Strategy estimated the population of wild dogs in the greater Kafue ecosystem (including GMAs) as 110 adults/yearlings in 11 packs (IUCN/SSC 2015). The latter estimate appears to be based solely on Carlson et al. (2004) and, therefore, may not accurately depict the population of wild dogs inhabiting the greater Kafue ecosystem. Alternatively, it may indicate a decline in the number of Kafue’s wild dogs since 2012. The time period of our study (2007-2012) allows for a more accurate reconstruction of population trends of wild dogs in Kafue by filling a data gap between previous (Buk 1995; Woodroffe et al. 1997) and more recent assessments (IUCN/SSC 2015).

The goals of this study were to summarize all available sighting data from the southern Kafue and compile images of wild dogs into a photographic catalogue for the region. African wild dogs have a mottled black, tan and white coat. Each pattern is unique, and allows for individual identification as well as confirmation of re-sightings of individual dogs over temporal and spatial scales (Skinner and Smithers 1990). By making available photographic records along with data on pack size, locations, sex, and presence of pups, this work also serves as a reference for future monitoring efforts. In particular, individually identified dogs provide continuity regarding pack or sub-population persistence and may aid in documenting long-distance dispersal. African wild dogs can live up to ten or 11 years in the wild (Creel and Creel 2002; Woodroffe, McNutt, and Mills 2004), therefore, at least some dogs documented here are expected to still be alive. Dogs that may have since died can still be photographically matched to other data sources to reconstruct pack histories including dispersal events.

We encountered wild dogs opportunistically and obtained additional sighting data from hunting operators and photographic tour guides each year. Because the road network in southern Kafue is sparse and tourism rates are low (Siamudaala, Nyirenda and Saiwana 2009), detection rates of dogs were probably low. Thus, our results should be viewed as minimum counts. Nevertheless, by compiling empirical information on wild dog packs in the southern Kafue ecosystem, this project supports the mandate of Zambia’s National Conservation Plan for the African Wild Dog to gather data on the population status and map distribution of the species in Zambia (Chansa, Zyambo and Kampamba 2005; ZAWA 2009). Further, this work feeds in to a growing number of conservation initiatives on wild dogs including the IUCN’s (2012, 2015) calls for survey information (Woodroffe and Sillero-Zubiri 2012; IUCN/SSC 2015). Finally, the greater Kafue ecosystem comprises around 13% of the nearly 520,000km<sup>2</sup> Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) which was officially formed in March 2012. Thus, our study contributes to national, regional and international conservation strategies (ZAWA 2009; Secretariat 2014; IUCN/SSC 2015) for African wild dogs across a vast landscape in southcentral Africa.

## Methods

### Study area

The greater Kafue ecosystem, which consists of NKNP and SKNP and the adjoining GMAs, comprises a contiguous protected area of approximately 66,500km<sup>2</sup> in western Zambia. A tarmac road (M9) that bisects the KNP (approximate latitude 43°58’S) unofficially distinguishes the northern from the southern portions of the ecosystem. South of the M9, one unpaved road through the GMAs east of the park sees daily vehicular traffic as far as Itezhi

town. Beyond Itezhi Tezhi, there exists a very limited network of roads (Figure 1) which receive light traffic consisting of locals traveling to distant villages and tourists visiting SKNP. This study took place in the SKNP and the adjoining GMAs of Mumbwa, Namwala, Nkala Bilibili, Bbilili, Sichifulo, Bilibili, Mulobezi and Mufunta that combined constitute the southern Kafue ecosystem, an area of approximately 34,500km<sup>2</sup> in size (Siamudaala, Nyirenda and Saiwana 2009)(Figure 1). During the study period, six safari operators had hunting camps in the GMAs. Two photo-tourism camps were operating in the SKNP with three more in the GMAs.

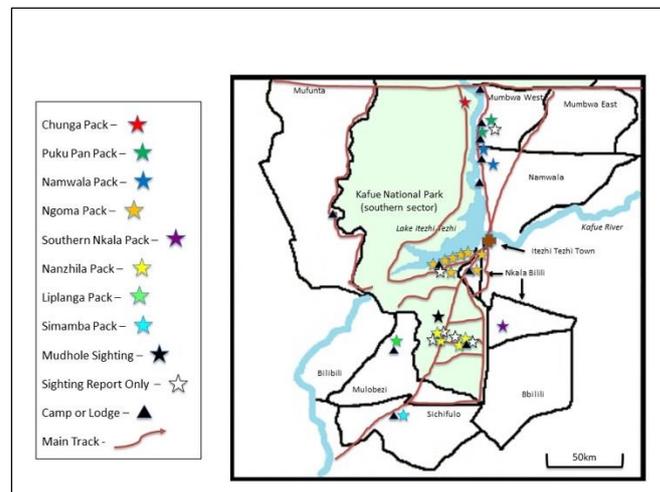


Figure 1. Sighting distribution of African wild dogs in the southern Kafue ecosystem 2007-2012. Due to scale, markers show approximate locations. GPS coordinates given in Appendix I.

The KNP habitat consists mainly of open grasslands with *Brachystegia-Julbernardia* woodlands in the north and *Colophospermum mopane* in the south (Mitchell, Shenton and Uys 1965). The NKNP generally experiences higher amounts of rainfall than the SKNP resulting in taller grasslands and grassy dambos that concentrate game in the NKNP. In contrast, the SKNP has a larger woodland mosaic and a more patchy distribution of grasslands and game. The two main water sources in the SKNP are the Kafue River and Lake Itezhi-Tezhi. The climate is tropical or sub-tropical, with one dry season (June to mid-November) and one rainy season (late November to end May) each year. Other large carnivores in the ecosystem that may compete with the African wild dog include lion *Panthera leo*, leopard *P. pardus*, spotted hyaena *Crocuta crocuta* and cheetah *Acinonyx jubatus*.

## Data collection

### Sightings and records

Direct encounters of wild dogs were made opportunistically by one of the authors (PAW) while conducting research on lions from 2007-2012. Lion research each year involved driving all roads throughout the SKNP, as well as seasonal hunting tracks that crisscross the GMAs, searching for lions and sign and conducting audio playbacks to attract lions. Most driving occurred from pre-dawn to one hour after dusk. Playbacks at times attracted wild dogs.

Audio playbacks consisted of pre-recorded vocalizations of prey in distress (buffalo calf or wild pig) transmitted from a rechargeable mp3 player (iPod Nano, 16GB, Apple, Inc. Cupertino, CA, USA) connected by speaker jack to a battery-powered handheld megaphone (Model 1200, ThunderPower Megaphones, Rancho Dominguez, CA, USA). Through field-testing, playbacks were determined to be audible (to humans) up to a minimum distance of 1.5km from the sound source depending on the wind.

Additional photographs, video footage and sighting records were obtained by visiting safari and photographic camps in the region and interviewing personnel who had been tested using guide books as to their ability to distinguish African wild dogs from all other species. Because lion research and most camps operated seasonally, most photographs were taken between

May–December and do not necessarily represent seasonality in occurrence of wild dogs in the region. Similarly, most photographs were taken during daylight hours which reflected the timing of lion surveys and camp operations rather than the activity patterns of wild dogs. Sighting locations were recorded as GPS coordinates (latitude and longitude) and identified as falling within the SKNP or a specific GMA (Appendix I).

#### *Image capture*

For direct encounters, photographic images and/or video footage were captured using a Nikon 35mm D3300 digital camera with Nikkor AF70-300mm f/4.5-6.3 lens (Nikon USA Inc., Melville, New York, USA) and/or Canon HD-CMOS Vixia HG21 digital camcorder with 4.8-57.6mm 12x optical zoom lens (Canon USA Inc., Melville, New York, USA). Other photographs were received as stills or digital images and video footage (Appendix I). Photographs were viewed using Apple Preview Version 8.1 (Apple, Inc., Cupertino, CA, USA). Still photographs from video footage were captured using iMovie '11 software Version 9.0.4 (Apple, Inc., Cupertino, CA, USA).

#### *Identification of packs and individual African wild dogs*

For each sighting, photographs and/or video footage were analysed to count the total number of dogs present. Because some dogs may have gone undetected in the photographic or video records, total counts represent minimum numbers. Colour patterns were used to assign each dog a unique identification (ID) code (Maddock and Mills 1994) using left and/or right sides depending on the available images. Where photographs captured side or front views that could not be matched to existing IDs or confirmed as unique dogs, the additional views were included in the catalogue as “unidentified dogs”. Thus, “unidentified dogs” may represent different views of dogs with existing ID codes. Alternatively, they may represent additional dogs to the minimum total count.

Most photo-documented encounters provided some usable images, however in one sighting the dogs were caked in mud and positive IDs could not be made. Photographic quality varied, and in a few instances low light resulted in dark or blurry photographs. Over-enlarging digital images resulted in pixilation. While every effort was made to ID all dogs in each sighting, IDs were not assigned to dogs for whom at least one side or the front view was not available. ID photographs obtained from video footage via screen capture did not always provide as clear an image as the raw video. Therefore, video footage is provided (see DOI: 10.6084/m9.figshare.5619187) for future investigators.

Packs were assigned a colloquial name corresponding to a camp or other feature close to where the first sighting occurred. Visible genitalia in photographs and sexually dimorphic behaviors, e.g. raised-leg urination, allowed definitive sex assignment of some individuals. Pregnant or lactating females were identified by the presence of distended nipples. All other dogs were assigned as sex “unknown”. Some dogs were identifiable as juveniles (young of the year) based on their size. Wild dogs in Kafue pup early in the dry season (~June) (Mitchell, Shenton, and Uys 1965), thus for dogs first observed as juveniles, year of birth could be assigned with accuracy. We made no assumptions regarding pack social structure. With the exception of young of the year, we considered all dogs as “adults”. Apart from noting lactating females, we made no attempt to distinguish “mature” (breeding) adults from non-breeding adults. ID codes consisted of pack name, sex, and a unique number within the pack, e.g. “PUK-1M” denotes the pack named Puku Pan (PUK), sex as male (M), and first dog in the pack to be assigned an ID (1).

#### *Spatial distribution of African wild dog sightings in southern Kafue ecosystem*

Sightings were recorded as GPS locations and initially mapped using Google maps. Thereafter, sightings were depicted on a simplified map of the southern Kafue ecosystem (Figure 1). Each pack was assigned a differ-

ent colour symbol, and re-sightings of the same pack were indicated by multiple symbols of the same colour. Due to the scale of the map, the locations shown by symbols are close approximations. GPS locations are listed in Appendix I.

#### *Catalogue compilation*

Sightings were organized by pack and location (from north to south) to create an Identification Catalogue of dogs in the southern Kafue ecosystem (DOI: 10.6084/m9.figshare.5619187). ID photographs include the date the pictures were taken. For pups that were re-sighted as adults, photographs of the older age classes were used. Because ID photographs were not obtained for all dogs, the total count may be greater than the number of dogs shown in the catalogue.

## Results

A total of 29 sighting records of African wild dogs in the southern Kafue ecosystem were obtained. Sightings occurred from Chunga near the M9 tarmac road that bisects KNP in the north to Sichifulo GMA in the south (Figure 1).

Twenty-two of the 29 sightings were documented with photographs and/or videos. Of the 22 photo-documented records, ten were collected by one of the authors (PAW) during chance encounters ( $n=5$ ) and when wild dogs approached in response to playbacks of prey in distress broadcast to attract lions ( $n=5$ ). The remaining 19 sighting reports (12 with photo documentation, seven without) were obtained from hunting and tourist camps, including one dog photographed at a tourist camp by the Painted Dog Research Trust. An inventory of sightings and photographic credits is given in Appendix I.

Eight packs were documented, and 90 dogs were identified. This excludes a possible recount of two dogs in the Namwala Pack that may have been re-sighted in the Puku Pan Pack which, if unique individuals, would bring the total to 92 dogs. Of these, 73 dogs were assigned unique ID codes (including the two possible recounted dogs noted above doi: 10.6084/m9.figshare.5619187). No entanglement of wild dogs in wire snares, or with obvious snare injuries i.e. missing feet, neck or leg scars, was observed, photographed, or otherwise reported.

Mean pack size was  $X \pm SE = 8.7 \pm 1.2$  adults/pack, range 4–13,  $n=7$  packs. Including young of the year, mean pack size was  $X \pm SE = 11.5 \pm 1.0$  dogs/pack, range 7–19,  $n=8$  packs. Due to possible issues with detectability (especially when working only from photographs), pack sizes reported here should be considered minimum counts.

Five litters were documented; four through observation of packs containing young of the year and one through observation of a lactating female. One additional litter was inferred from observation of a heavily pregnant female assumed to have subsequently whelped (Table 1).

Of the 29 sightings, 18 occurred within the SKNP while 11 occurred in GMAs (Figure 1, Table 1). Overall, dogs were seen in five of the eight southern Kafue GMAs. At least one pack was seen using both the SKNP and the adjoining GMA.

One pack (Ngoma) was re-sighted in three consecutive years, while another pack (Nanzhila) was re-sighted in non-consecutive years. Sightings were most common around lodges and camps. Although sighting data were insufficient to calculate home range sizes, multiple re-sightings of the Ngoma Pack within an approximate 50km<sup>2</sup> area indicated that the pack showed some multiannual fidelity to the Ngoma/Nkala area (Figure 1, Table 1, see DOI: 10.6084/m9.figshare.5619187). Similarly, the adult male photographed in 2009 near Nanzhila Lodge was re-sighted with a pack in 2012 within a kilometre of its original location.

Table 1. Pack size (minimum number detected), age class, and sex composition of African wild dogs comprising eight packs observed in the southern Kafue ecosystem, Zambia between 2007-2012.

Pack Name	Sighting Date	Total Count	Age Class	Sex
Chunga ZAWA	6 May 2011	15	Adults and pups seen	1 Male, 7 Unknown
Namwala	14 June 2010	7	7 Adults	4 Males, 2 Females, 1 Unknown
Puku Pan	7 Mar 2011	13	13 Adults	5 Males, 1 Female, 4 Unknown
Ngoma	19 May 2009	5	5 Adults	5 Males
	21 June 2009	10	10 Adults	8 Males, 1 Female, 1 Unknown
	24 Nov 2010	16	11 Adults, 5 Juveniles	11 Males, 4 Females, 1 Unknown
	6 Mar 2011	9	5 Adults, 4 Juveniles	7 Males, 1 Female, 1 Unknown
	4 May 2011	4	4 Adults	3 Males, 1 Unknown
	19-22 Oct 2011	7	4 Adults, 3 Juveniles	5 Males, 2 Females
Southern Nkala	15 May 2012	12	12 Adults	12 Unknown
Nanzhila	27 Sept 2012	10	4 Adults, 6 Juveniles	2 Males, 8 Unknown
Liplanga	28 Sept 2008	8	8 Adults	8 Unknown
Simamba	27 June 2007	8	8 Adults	8 Unknown

## Discussion

We identified 90 African wild dogs in eight packs in the southern Kafue ecosystem during the time period 2007-2012. Because sample sizes were small and our data spanned several years, it could not be verified in all cases if dogs seen in one year were still present and not detected in subsequent years, if they had left the area, or had died. While some dogs were documented as using the same areas across years suggesting that they were members of resident packs, the sighting of a small number of dogs does not necessarily indicate a resident pack (IUCN/SSC 2015). For these reasons, we do not present the  $\geq 90$  dogs as an estimate of population size for the southern Kafue ecosystem. Similarly, we did not attempt to calculate number of dogs/km<sup>2</sup> (density). However, documenting individual dogs, and locations and sizes of distinct packs along with reproductive events adds greatly to our knowledge of wild dogs in the region. For example, the most current (2015) estimate for the greater Kafue ecosystem is 110 dogs (IUCN/SSC 2015); a figure apparently based on a 2003-2004 study that was restricted to the NKNP (Carlson, Carlson, and Bercovitch 2004; Purchase, Mateke, and Purchase 2007). Our findings of multiple reproducing packs in the southern Kafue ecosystem for several years following 2004 strongly suggest that the estimate of 110 dogs for the greater Kafue ecosystem is probably low.

Mean pack size in this study was similar to those reported for wild dogs across Zambia between 1993-1994 (Buk 1995): 8.3 dogs/pack in Kafue ( $n=83$  sightings), 8.8 dogs/pack in Luangwa Valley ( $n=24$  sightings), 11.8 dogs/pack in Liuwa Plains ( $n=21$  sightings), 6.6 dogs/pack in Sioma-Ngwezi ( $n=8$  sightings), and 5.5 dogs/pack in Lower Zambezi ( $n=16$  sightings). Whether Buk's (1995) pack sizes included young of the year was not specified. More recent studies have reported  $X=5.6$  adults/pack, range 2-7, ( $n=6$  packs) in South Luangwa (Becker et al. 2013), and 22 dogs in 2 packs in Liuwa Plains (Droge et al. 2017). Mean pack size in the 2003-2004 NKNP study was  $X=11.6$  adults/pack, range 5-25 ( $n=9-10$  packs)(Carlson, Carlson, and Bercovitch 2004). Thus since at least 2003, average pack sizes observed in the greater Kafue ecosystem have met or exceeded the minimum 5 adults/pack considered necessary for hunting and reproductive success (Courchamp and Macdonald 2001).

Both in the park and the GMAs, the majority of dog sightings occurred in the vicinity of camps which is likely attributable to a greater probab-

ity of dog encounters due to increased human activity along the localized networks of seasonal driving tracks. For example, although the pack's home range was undoubtedly much larger, the Ngoma Pack was re-sighted repeatedly within a 50km<sup>2</sup> area that encompassed both a photographic lodge and hunting camp as well as an office for the Department of National Parks and Wildlife (DNPW)(formerly Zambia Wildlife Authority ZAWA). In Kruger National Park where there is an extensive road network and high levels of tourism, engaging tourists to share sightings and photographs can prove a highly effective means of surveying for wild dogs (Marnewick et al. 2014). However, the SKNP has a very limited road network, few photographic camps, and low visitation by tourists (Siamudaala, Nyirenda and Saiwana 2009), all of which decrease detection rates (Marnewick et al. 2014). In contrast, safari hunters drove extensive seasonal tracks through the GMAs from May-November on a daily basis. With superb acuity, local trackers aboard hunting vehicles note sign of any carnivore, including wild dogs (White, pers. obs.). Given this increased coverage, probability of detecting wild dogs in the GMAs may have been higher than in the park, yet hunters also rarely encountered dogs. African wild dogs occur at generally low density under all conditions (Creel and Creel 2002). A previous estimate of 0.013 dogs/km<sup>2</sup> was made for the KNP excluding the GMAs (Woodroffe and Sillero-Zubiri 2012). A low density of dogs coupled with their wide-ranging habits and the vegetative cover in the southern Kafue ecosystem may all have contributed to the low number of encounters reported.

Even using playbacks, the chance of detecting wild dogs may have been low. Dogs were attracted to our playbacks at times, however dogs might also have responded adversely to avoid encountering large predators, e.g. lions. Wild dogs are harassed, kleptoparasitized, and killed by lions, thus tend to avoid areas where lion density is high (Creel and Creel 1996; Mills and Gorman 1997; Creel, Spong and Creel 2001; Swanson et al. 2014). However, most studies reporting wild dog avoidance of playbacks used vocal repertoires that contained sounds of lions and/or hyenas on a kill (Creel and Creel 1996; Webster, McNutt and McComb 2011). During our study period, encounter rates with lions and hyenas were low, and both cheetah and leopard were present. When hyenas responded to our playbacks, it was usually as singles or in pairs (White, unpublished data). Although wild dogs rarely scavenge, packs can chase hyenas away from food (Schaller 1972; Creel and Creel 1996). Wild dog pups are occasionally killed by leopards (Woodroffe, McNutt and Mills 2004), but appropriation of leopard kills by dogs has also been reported (Creel

and Creel 1995). Although little has been written describing direct interactions between wild dogs and cheetahs, cheetah are highly susceptible to kleptoparasitism by other carnivores (Durant 1998, 2000), and it may be anticipated that a pack of dogs could successfully chase a cheetah from its kill (Caro 1994). Therefore, it bears considering that wild dogs in the southern Kafue ecosystem may have been more likely to respond to our playbacks, which contained sounds only of prey in distress, if they perceived a chance to steal a kill from a cheetah, leopard, or lone hyena against a relatively low risk of encountering lions. Experiments to test responses of wild dogs to playbacks of only prey in distress where lion densities vary would be of interest.

Alternatively, it is possible that wild dogs responded to our playbacks with an expectation of finding a prey animal caught in a wire snare. As in most African reserves (Lindsey et al. 2013), bushmeat poaching with snares occurs in the Kafue (Siamudaala, Nyirenda and Saiwana 2009). Accidental snaring is among the top threats to wild dogs (IUCN/SSC 2015) and constitutes a major source of mortality in some areas (Woodroffe et al. 2007). It is noteworthy that none of the wild dogs seen or photographed in this study showed any evidence of snare entanglement, neither were snare injuries mentioned in any dog sighting report, although lions and hyenas with snare injuries were seen on occasion (White, unpublished data). Snare injuries may be harder to detect among dogs that are not closely monitored compared to intensively studied packs (Woodroffe et al. 2007). However, Carlson et al. (2004) also did not report any snaring in 9-10 study packs in NKNP even though snares were observed on lions and hyenas in their study area during the same time period. Snaring is strongly correlated with human development around national parks and GMAs (Watson et al. 2015), and was considered a primary limiting factor of wild dogs in the heavily encroached South Luangwa, where four of six monitored packs contained snared dogs (Becker et al. 2013). During this study, encroachment followed by ZAWA-enforced evictions occurred sporadically in the southern Kafue GMAs of Mumbwa and Sichifulo (White, pers. obs.). Data on current levels and patterns of snaring in the greater Kafue ecosystem are needed to fully evaluate this threat to wild dogs, other carnivores, and their prey.

In summary, this study addresses a data gap on wild dogs in the southern Kafue ecosystem, and by extension, contributes to our knowledge of wild dogs in the greater Kafue ecosystem and the larger landscape of the KAZA TFCA. In southern Africa, nearly 90% of wild dog populations are transboundary (IUCN/SSC 2015), and it is estimated that KAZA alone holds nearly one-quarter of the world's remaining wild dogs (Secretariat 2014). Wild dogs can live up to ten or 11 years in the wild (Creel and Creel 2002; Woodroffe, McNutt and Mills 2004). Dogs born during this study that may still be alive represent known-aged wild carnivores - a rare commodity, while photographic records of dogs that are no longer alive can be used alongside other data sources to reconstruct pack histories and movements, thereby improving our understanding of population trends. Thus, this work contributes on several levels to our knowledge of wild dog populations in an area considered critical for the long-term survival of the species (Secretariat 2014; IUCN/SSC 2015).

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## Biographical sketch

**Paula White** is a wildlife biologist with over 30 years of experience, including 14 years of field work in east and south-central Africa studying carnivores. She received a BSc in Biology from UC Santa Barbara, and a MSc and PhD from UC Berkeley. She is currently a Senior Research Fellow at the Center for Tropical Research, UC Los Angeles.

**Ayong Kim** received her Bachelor's degree at UC Los Angeles in 2012. She followed her studies working in a laboratory at USC and eventually at the Los Angeles Zoo. She recently graduated in 2017 with her Master's in Animal Behaviour and Conservation at Hunter College in New York.

Appendix I. Inventory of African wild dog sightings, photographs and video footage used in this study. The date, relative location within the southern Kafue ecosystem, colloquial name of specific location, type of record, photograph credit, and GPS location are provided for each sighting. Continued on following page.

Date	NP or GMA	Location	Photo Y/N	Video Y/N	Pic ID Nos.	Video ID Nos.	Notes	Photo Credit	GPS S	GPS E
27-Jun-07	Sichifulo GMA	Simamba Camp vicinity	Y	N	STA40990-STA40996			Kevin Louw	16°40'46.02"S	25°38'24.60"E
28-Sep-08	Sichifulo GMA	Simamba Camp vicinity	Y	N	STA40990-STA40996			Kevin Louw	16°40'46.02"S	25°38'24.60"E
19-May-09	Nkala GMA	North Nkala Loop	Y	N	DSC_1963-DSC_1967		n=6	PAWhite	15°57'4.08"S	25°52'7.68"E
21-Jun-09	Nkala GMA	Namitwe Loop	Y	N	DSC_2359-DSC_2402		n=10+; 1 lact F very white, >6MM	PAWhite	15°50'23.40"S	25°59'55.32"E
01-Sep-09	S Kafue NP	Nanzhila Camp vicinity	Y	N	NanzhilaKafueZambiaSept09		Nanzhila Camp vicinity	Painted Dog Research Trust	16°16'26.82"S	25°55'3.66"E
01-Jan-10	Mumbwa West GMA	Puku Pan Camp	N	N	None		n=7; Dam 3	Puku Pan Staff	15°13'40.77"S	25°59'16.26"E
14-Jun-10	Namwala GMA	Mvia Valley	Y	N	2010 Batch 1 036-057		F heavily pregnant, 1Ad M, 5 subAdults	PAWhite	15°22'10.14"S	26° 1'23.70"E
18-Aug-10	S Kafue NP	Nanzhila Camp Dambo	N	N	None		n=1	Nanzhila Camp Staff	16°16'29.82"S	25°54'34.98"E
21-Aug-10	S Kafue NP	Nanzhila Camp Dambo	N	N	None		n=2	Nanzhila Camp Staff	16°16'29.82"S	25°54'34.80"E
07-Sep-10	S Kafue NP	Nanzhila Camp vicinity; Main Rd to Dundumwezi	N	N	None		n=4	Nanzhila Camp Staff	16°16'40.68"S	25°48'52.94"E
20-Sep-10	S Kafue NP	Nanzhila Camp Jct	N	Y	None	20 Sept 2010 Nanz	n=4; dark dogs very little white; Big Bridge Main Rd	PAWhite	16°16'44.96"S	25°48'52.40"E
19-Nov-10	S Kafue NP	W of Nanzhila, N of Mulobezi	N	Y	None	129	n=11; Kill in Muddy Pond	PAWhite	16°12'46.00"S	25°48'51.00"E
24-Nov-10	S Kafue NP	Cooke's Camp lakeshore	Y	N	D1_1131-D1_1485		n=19 dogs ("last time 19 seen"); old M very white	Andrea Porro	15°52'40.36"S	25°54'35.56"E
24-Nov-10	S Kafue NP	Cooke's Camp lakeshore	Y	N	IMG_8234-IMG_8384			Chris Cooke	15°52'41.71"S	25°54'32.58"E
06-Mar-11	S Kafue NP	Cooke's Camp lakeshore	Y	N	1D_6431-1D_6544		n=6-7 ("subpack" since Nov 2010); >2 with tails virtually all white, >1 dog very tan	Andrea Porro	15°52'50.94"S	25°54'18.74"E
07-Mar-11	Mumbwa West GMA	Puku Pan Camp near airstrip	Y	N	IMG_1749-IMG_1772			Puku Pan Staff	15°12'8.41"S	26° 1'55.92"E
04-May-11	S Kafue NP	Cooke's Camp vicinity	Y	Y	DSC_5089-DSC_5100	00157-00163	n=12; F very white; S of lake and W of Cookes' Camp, darting lions	PAWhite	15°54'8.35"S	25°49'14.02"E
06-May-11	S Kafue NP	Chunga ZAWA HQ	N	Y	None	00178-00181	At night, darting lions	PAWhite	15° 1'20.42"S	25°58'14.00"E
07-Jun-11	S Kafue NP	Cooke's Camp drive	N	N	None		n=1 dog seen with trax of many more	PAWhite	15°53'0.31"S	25°52'40.86"E
19-Oct-11	S Kafue NP	Cooke's Camp lakeshore	Y	N	1D_3924-1D_4240			Andrea Porro	15°51'20.84"S	25°56'33.35"E

Date	NP or GMA	Location	Photo Y/N	Video Y/N	Pic ID Nos.	Video ID Nos.	Notes	Photo Credit	GPS S	GPS E
22-Oct-11	S Kafue NP	Cooke's Camp lakeshore	Y	N	1D_4241-1D_4510			Andrea Porro	15°51'27.89"S	25°56'18.12"E
27-Oct-11	S Kafue NP	Cooke's Camp	N	N	None		Dogs chased impala and killed it in camp	Andrea Porro	15°52'12.70"S	25°52'50.46"E
29-Oct-11	Nkala GMA	Nkala Camp	Y	N	DSC_6654-DSC_6660	305	n=6	PAWhite	15°54'19.01"S	26° 0'24.39"E
30-Oct-11	Nkala GMA	Ngoma Plains	Y	Y	DSC_6668-DSC_6708	00306-00307	Plains bet Nkala Camp & Ngoma	PAWhite	15°54'41.56"S	25°58'11.91"E
30-Apr-12	S Kafue NP	Nanzhila Camp Jct	N	N	None		Big Bridge Main Rd; 2 dogs	Nanzhila Camp Staff	16°16'43.86"S	25°48'51.30"E
07-Jun-12	S Kafue NP	Nanzhila Camp vicinity	N	N	None		Mafunta Loop; 2 dogs	Nanzhila Camp Staff	16°17'0.78"S	25°47'30.20"E
15-May-12	Nkala GMA	Southern GMA/NP Boundary	Y	N	IMG_1976-IMG_2029		n=9-10 dogs, on kill, one with very floppy ear	Jaco Swanepoel	16°11'3.31"S	26° 4'44.91"E
29-Jul-12	Namwala GMA	Kaingu Camp vicinity	Y	N	IMG_1527-IMG_1529			Kaingu Staff	15°17'55.03"S	25°59'3.05"E
27-Sep-12	S Kafue NP	Nanzhila Camp	N	Y	10 dogs	MOV05182	Nanzhila Camp	Nanzhila Staff	16°16'44.64"S	25°55'6.12"E