

Research article

## Retrospective study of mortality of captive African wild dogs (*Lycaon pictus*) in a French zoo (1974–2013)

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**Abstract**

The zoological and medical records and necropsy reports of 193 captive African wild dogs (*Lycaon pictus*) that died at the Réserve Africaine de Sigean (France) from 1974 to 2013 were examined. The goal of this study was to determine the most common causes of mortality in order to highlight issues on which to focus, as well as the influence of age, gender and place of birth. Cannibalism by cagemates was the most prevalent cause of death in neonates and juveniles. The most common causes of mortality were reproductive diseases in adult females and cardiovascular conditions in adult males. Geriatric African wild dogs were mainly affected by urinary diseases and tumoral processes. The findings of this study could influence management recommendations for the captive African wild dog population.

### Introduction

The African wild dog (*Lycaon pictus*, Temminck 1820) is one of the most endangered canids of Africa. Although African wild dogs were widely distributed in sub-Saharan Africa, habitat fragmentation has led to marked declines in their distribution and population (Creel et al. 2004; Woodroffe et al. 2007; Woodroffe and Sillero-Zubiri 2012). Most of the causes of this decline are linked to human activities, such as conflict with livestock and game farmers, road accidents, or infectious diseases transmitted by domestic dogs, such as canine distemper (Gascoyne et al. 1993; Van Heerden et al. 1995; Hofmeyr et al. 2000). African wild dogs have been considered “Endangered” by the International Union for Conservation and Nature since 1990, and their wild population was estimated at 6,600 individuals in 2012 (Woodroffe and Sillero-Zubiri 2012). European Association of Zoos and Aquaria (EAZA) institutions housed 273 African wild dogs (152 males and 121 females) in 2009 (Verberkmoes and Verberkmoes 2009). This captive population is a valuable source for education, conservation and veterinary purposes.

Veterinary literature for African wild dogs is mainly focused on case reports, dealing especially with reproductive, tumoral or infectious conditions (Cho et al. 2006; Newell-Fugate and Lane 2009a, b; Jankowski et al. 2012; McAloose et al. 2012).

The aim of this retrospective study of mortality in the captive population held in a zoo between 1974 and 2013 was to highlight issues on which to focus. To better understand the prevalence of different causes of death, mortality was compared between gender and age classes.

### Methods

The deaths of 193 African wild dogs held at the Réserve Africaine de Sigean (France) were recorded during the period 1974–2013. For all these deaths, the zoological and medical records were examined, as well as necropsy reports when available. The data obtained were then tabulated by body system involved, age, gender and birthplace (wild versus captive). The body systems in which the causes of death were categorised as follows: cardiovascular, digestive, integumentary, musculoskeletal, neurological, reproductive, respiratory and urinary systems. To

**Table 1.** Prevalence of cause of death (%) by body systems and age classes of captive African wild dogs (*Lycaon pictus*) held at Sigean between 1974 and 2013. <sup>a</sup>Main causes of mortality (prevalence >20%).

Body system	Age class				All ages (n = 193)
	<1 month (n = 129; 66.8%)	1 – <18 months (n = 26; 13.5%)	1.5 – <10 years (n = 19; 9.8%)	≥10 years (n = 19; 9.8%)	
Cardiovascular	0.0	0.0	10.5	21 <sup>a</sup>	3.1
Digestive	0.0	0.0	26.3 <sup>a</sup>	5.3	3.1
Integumentary	0.0	0.0	5.3	10.5	1.5
Musculoskeletal	0.0	7.7	0.0	0.0	1.0
Neurologic	0.0	0.0	0.0	5.3	0.5
Reproductive	0.0	0.0	31.6 <sup>a</sup>	5.3	3.6
Respiratory	6.2	3.8	0.0	5.3	5.2
Urinary	0.0	0.0	0.0	42.1 <sup>a</sup>	4.1
Cannibalism/trauma	86 <sup>a</sup>	62.5 <sup>a</sup>	10.5	0.0	66.8 <sup>a</sup>
Others	7.8	26.9 <sup>a</sup>	0.0	0.0	8.8
Unknown	0.0	0.0	15.8	5.3	2.1

these body systems, three categories were added: cannibalism or trauma, others and unknown. Prevalence of mortality within each category was determined for age and gender when known; a Chi-square test was used to test for any differences in the causes of mortality between genders, and between birthplaces ( $\alpha = 0.05$ ).

The African hunting dogs studied were divided into four age classes: less than 1 month (neonate), 12 months to less than 18 months (juvenile), 1.5 years to less than 10 years (adult), and more than 10 years (geriatric). During their development, pups stay with their mother in the den until one month of age. Sexual maturity is reached around the age of 18 months. The adult and geriatric age ranges were based on the total life span of African wild dogs (up to 14 years) (Woodroffe and Sillero-Zubiri 2012).

The cause of death for each individual was determined using the medical records and necropsy reports. For the few cases where a conclusion was not clearly identified in the records, the clinical signs and necropsy lesions were used by the authors to determine a cause of death. If several conditions could have led to the death of an animal, the most important one (clinical history prior to death, necropsy lesions) was used to classify the case as described before. For euthanased animals, the relevant conditions in their medical history were analysed for classification.

## Results

Necropsy reports were available for 65 individuals (34%). This relatively low number can be explained by the high number of neonates not necropsied as they were eaten by their parents. The zoological and medical records were also examined to determine the cause of death of other animals. The cause of death was not determined for four individuals (2%). The prevalence of disease within the 11 categories of this study is presented in Table 1. The causes of death sorted by gender for individuals over 1 month old are given in Table 2.

### Survival to over one year

Among 178 births recorded during the 1974–2013 period, only 42 (23.6%) survived for more than one year. The survival rates at one year for each sex were quite similar, and not significantly different ( $P > 0.05$ ): 51.6% (16/31) for males, and 60% (12/20) for females, including only individuals whose gender was known.

### Neonate (less than 1 month)

In this age class (n = 129), the main cause of death is cannibalism by parents, representing 86% of all the deaths recorded. It is important to note that the number of pups, and consequently the occurrence of cannibalism, is underestimated; of the 52 litters born at the Réserve Africaine de Sigean between 1974 and 2013, 37 (71%) were eaten by cagemates (parents or pack members) in the first 48 hours. The number of pups per litter was determined by examination of the zoological records and keepers' notes. In some cases, the pups were not seen or heard, and so only one pup was arbitrarily counted in our study. A total of 126 pups were eaten by cagemates during the period studied, 70 (56%) in the first 48 hours, 99 (79%) before the age of 10 days.

**Table 2.** Causes of death by gender in captive African wild dogs (*Lycaon pictus*) of more than 1 month of age held at Sigean between 1974 and 2013.

Body system	Sex					
	Total (n = 64)	Males (n = 33)		Females (n = 31)		
Cannibalism/trauma	18	28%	10	30%	8	26%
Urinary	8	12%	4	12%	4	13%
Reproductive	7	11%	0	0	7	23%
Others	7	11%	5	15%	2	6%
Cardiovascular	6	9%	6	18%	0	0
Digestive	6	9%	1	3%	5	16%
Unknown	4	6%	4	12%	0	0
Integumentary	3	5%	1	3%	2	6%
Musculoskeletal	2	3%	1	3%	1	3%
Respiratory	2	3%	1	3%	1	3%
Neurologic	1	2%	0	0	1	3%

**Table 3.** Causes of death by place of birth in captive adult and geriatric African wild dogs (*Lycaon pictus*) held at Sigean between 1974 and 2013.

Body system	Place of birth					
	Total (n = 38)		Captive (n = 28)		Wild (n = 10)	
Urinary	8	21%	7	25%	1	10%
Reproductive	7	18%	5	18%	2	20%
Cardiovascular	6	16%	4	14%	2	20%
Digestive	6	16%	5	18%	1	10%
Unknown	4	11%	2	7%	2	20
Integumentary	3	8%	2	7%	1	10%
Cannibalism/trauma	2	5%	1	4%	1	10%
Neurologic	1	3%	1	4%	0	0
Respiratory	1	3%	1	4%	0	0
Musculoskeletal	0	0	0	0	0	0
Others	0	0	0	0	0	0

The other causes of death for this age class were bronchopneumonia (6.2%; *Escherichia coli* isolated in four cases, *Streptococcus pneumoniae* in three and *Staphylococcus aureus* in three); foetal distress due to protracted or difficult parturition (4.6%); or artificial breeding failure (2.3%).

#### Juvenile (12 to 18 months)

In the juvenile age class (n = 26), cannibalism and trauma represent the main cause of death with 62.5% of individuals affected. 13 (50%) were eaten by cagemates, which occurred until the age of four months old. Traumas were the consequence of fights with cagemates.

Seven (26.9%) juveniles drowned when their den was flooded.

#### Adult (1.5 to less than 10 years)

In the adult age class (n = 19), two of the 11 categories represented more than 20% of mortality: reproductive and digestive. The reproductive issues concerned only females; five (26.3%) died of pyometra or chronic metritis, and one of placentitis. There were five (26.3%) deaths attributed to digestive diseases; obstruction was encountered in two cases, enteritis in one, and stomachal perforation in two. The latter was encountered in pregnant females at the end of gestation.

Traumas as a consequence of fights with cagemates and dilated cardiomyopathy each accounted for two cases (10.5%).

#### Geriatric (more than 10 years)

In the geriatric age class (n = 19), two of the 11 categories represented greater than 20% of the mortality: urinary and cardiovascular. In the urinary body system, all (eight individuals) were affected by advanced chronic renal disease, two of which were euthanased. Concerning the cardiovascular system, dilated cardiomyopathy and hemangiosarcoma were both encountered in two cases (10.5%). Death due to neoplasia accounted for five cases (26.3%) in this age class and was encountered in the following body systems: cardiovascular, integumentary and neurologic.

#### Gender

The statistical analysis performed showed a difference between genders for two body systems: reproductive and cardiovascular ( $P < 0.05$ ). Deaths following a reproductive condition only occurred in females, and mostly consecutive to pyometra and chronic

metritis. Cardiovascular diseases (four dilated cardiomyopathies and two hemangiosarcomas) were only fatal to males. Dilated cardiomyopathy was also encountered in adult and geriatric females but was never considered as the cause of death.

Cannibalism and trauma remained the main causes of death for both sexes (30 and 26% for males and females respectively). This could be explained by the relatively high level of cannibalism by parents in juveniles, and the social structure of this species.

#### Place of birth

The prevalence of causes of death within the 11 categories of this study are presented by place of birth in Table 3. There were no significant differences between captive and wild-born groups.

#### Discussion and conclusions

This retrospective study offers a valuable overview of captive African wild dog mortality in one zoological institution, as well as the influence of age, gender and place of birth on mortality. However, as a retrospective study using data from around a 40-year period, there may be several limitations associated with variations in record keeping, husbandry management, and pathologic and/or medical differences of opinion. Nevertheless, the goal of this study was to point out the more important causes of mortality in order to improve husbandry and medical management of captive African wild dog populations.

Overall, the most prevalent causes of mortality were cannibalism in neonates and juveniles, reproductive diseases in adult females and cardiovascular conditions in adult males. Geriatric African wild dogs were mainly affected by urinary diseases and tumoral processes.

This study demonstrated significant trends among age groups. The majority of neonatal deaths was attributed to cannibalism (n = 11; 86%). Cannibalism was seen mostly in neonate pups, during the first few days of life. Cannibalism is fairly spread among nondomestic carnivores and has been reported in black-footed ferrets (*Mustela nigripes*) during the first days of life, but can be seen until four months of age. The average age at death of these individuals was 2.1 days in a retrospective study conducted at the Smithsonian's National Zoo, USA (Bronson et al. 2007). The main reported causes of cannibalism are mothers' inexperience, stress, abnormal or dead offspring, and/or inadequate surroundings (Bronson et al. 2007). It is possible that some of the cases of suspected cannibalism were due to mothers eating stillborn or abnormal neonates, as carcasses were not available for necropsy. Several husbandry changes were initiated during the period studied in order to reduce neonatal mortality. Less invasive initial monitoring was undertaken to reduce mothers' stress, but did not influence cannibalism of pups. If zootechnical conditions are gathered, parental cannibalism could be countered by hand rearing and then reintroduction into the family group. Tranquillisation (perphenazine enanthate, 70 mg/adult IM) has been used successfully for the reintroduction of a pup to its parents after it had to be removed for medical reasons (T. Petit, pers. comm.).

Because of cannibalism, survival rate in our study (23.6%) was very poor for the first year of a dog's life compared to survival rates from free-ranging populations. Mean annual female pup survival was estimated at 35%, 48% and 75% in three different African areas, respectively Kruger National Park in South Africa, Northern Botswana, and Selous Game Reserve in Northern Tanzania (Creel et al. 2004; Woodroffe et al. 2007). Nevertheless, these survival rates were calculated on individuals once they have left the den, and so they do not include neonatal deaths, and potential cannibalism by the mother. The main factors described by authors affecting pup survival are predation by other large carnivores, mainly lions (*Panthera leo*) and spotted hyenas (*Crocuta crocuta*) (Creel et al. 2004).

In other large carnivore populations, parental incompetence is an important cause of pup mortality, representing 66.1% of all deaths recorded by the international studbook for maned wolves (*Chrysocyon brachyurus*) over the period 1980–1998, reaching 88.1% of the deaths in the first 30 days, and up to 94.5% in the first week (Maia and Gouveia 2002). Similarly, a retrospective study of mortality conducted on jaguars (*Panthera onca*) in North American institutions from 1982 to 2002 revealed that stillborn and neonatal deaths represented 81% of mortality in individuals less than two years old, and accounted for 20% of all deaths in the period studied (Hope and Deem 2006). Finally, maternal neglect was calculated to lead to 40% of neonatal deaths in a captive breeding programme for Iberian lynx (*Lynx pardinus*) between 2004 and 2010 (Martinez et al. 2013).

Traumas caused by cagemates were important in juveniles in our case. Intraspecific aggression was reported as the second cause of morbidity in captive Iberian lynxes, mostly between siblings, but rarely causes death in this species (Martinez et al. 2013). Maternal trauma was also recorded in black-footed ferrets until the age of 30 days (Bronson et al. 2007), and was also reported in one case in a captive Iberian lynx (Martinez et al. 2013). An entire litter was lost following the flooding of the den in the African hunting dog population we considered; changes were made to prevent other drownings.

Gastrointestinal diseases in neonate and juvenile age classes appear to be important causes of death in captive carnivores: 52.4% in black-footed ferrets (Bronson et al. 2007) and 17.6% in maned wolves (Maia and Gouveia 2002). Gastrointestinal diseases in these age classes represented 21.2–22.6% of morbidity in jaguars (Hope and Deem 2006). In the African wild dog population studied here, digestive conditions were only significant for adults.

Infectious diseases in neonate and juvenile age classes were less prevalent in our population (6.2 and 3.8% respectively) compared to a captive maned wolf population, in which they reached 17.4–33.1% (Maia and Gouveia 2002).

Adult females were significantly affected by reproductive diseases (26.3% of causes of death). Reproductive diseases were highly prevalent in geriatric captive jaguars in North America, and significantly more prevalent in females versus males (Hope and Deem 2006). The majority of reproductive diseases in this species were neoplastic, hyperplastic or cystic disease. Uterine affections have been previously described in African wild dogs, with a higher likelihood than in other wild canids (Moresco et al. 2009). Cystic endometrial hyperplasia and pyometra have been reported in intact captive females, and linked to prolonged progestative administration (Jankowski et al. 2012). Hope and Deem (2006) also found that medroxyprogesterone acetate exposure may increase the risk of reproductive disease. However, even if pathology of the uterine endometrium in painted dogs is higher following melengestrol acetate or deslorelin contraception, endometrial hyperplasia and pyometra can appear regardless of prior treatment with progestins or a GnRH agonist (Asa et al. 2014). In contrast, no contraception was administered to the females involved in our study, which highlights the possible role of exogenous progestatins in the development of uterine pathology in this species. Nevertheless, all the females involved were intact, and the influence of endogenous hormones is evident in such pathologies. The prevalence of uterine pathology had been shown to be higher in females that spent more years not reproducing, and only experiencing physiological reproductive cycles (Asa et al. 2014). Uterine pathology has also been linked to ovarian tumours in African wild and domestic dogs (Jankowski et al. 2012).

Hypovolaemic and endotoxaemic shock after uterine rupture facilitated by uterine adenomyosis was reported in a multiparous bitch (Newell-Fugate and Lane 2009a). Adenomyosis was never detected in our population, but two pregnant females died of

peritonitis consecutive to stomach rupture. Management was modified in order to distribute bone-free meal to pregnant females at the end of pregnancy to prevent bone perforation of the stomach wall.

In our study, chronic kidney disease, mainly due to glomerulonephritis, had been diagnosed in numerous adult to geriatric African wild dogs. Diagnosis was made on clinical pathology, as well as blood work. Treatment was based initially on diet change and angiotensin converting enzyme inhibitor, but evolved to advanced chronic renal failure leading to death or euthanasia of geriatric animals. Chronic renal failure has not been previously reported in African wild dogs but is widely described in domestic dogs, with a prevalence of 0.05 to 3.74% and demonstrated risk factors such as advanced age and periodontal disease, as well as specific breeds and small body size (O'Neill et al. 2013). Renal failure of unknown etiology was also the most prevalent renal disease in geriatric captive jaguars in North America (Hope and Deem 2006). Renal failure was reported as the main cause of morbidity and mortality in captive adult Iberian lynxes between 2004 and 2010, but was the consequence of a vitamin D toxicosis (Martinez et al. 2013).

Cardiovascular diseases were also widespread in adult and geriatric African wild dogs, and significantly more prevalent in males. Dilated cardiomyopathy was responsible for the death of two males but was also demonstrated on post mortem examination of adult and geriatric males and females. This condition was suspected to be a consequence of chronic kidney disease in most individuals. Hemangiosarcoma was demonstrated in two geriatric males, representing 10.5% of deaths in this age class. This neoplasm has previously been reported in a nine-year-old captive African wild dog, and described as a soft, red, lobulated mass attached to the periaortic fat between the level of the aortic valves and the pericardial reflection (Newell-Fugate and Lane 2009b).

Different kinds of neoplasms were encountered in this study, involving cardiovascular, integumentary and neurological systems. Several case reports of tumours have been described in the literature in adult to geriatric individuals; one hemangiosarcoma in a nine-year-old male (Newell-Fugate and Lane 2009b), one endometrial polyp in an eight-year-old female (Cho and Park 2006), as well as an uterine adenocarcinoma and ovarian granulosa cell tumours in adult females (Jankowski et al. 2012). A multilobular tumour of bone was also described in a 13-month-old female (McAloose et al. 2012). Females seem to be more affected than males as described in our study: 71% of deaths due to neoplasm were encountered in females, a significant sex difference ( $P < 0.05$ ). Captive female jaguars in North America also showed a high prevalence of neoplastic diseases, as well as uterine hyperplasia and pyometra (Hope and Deem 2006). Overall cancer incidence is considered three times higher in female than in male domestic dogs, a difference explained by the high rate of mammary cancer observed in bitches (Merlo et al. 2008).

Cannibalism of pups was widely prevalent through the study period in our population, as has been previously described in other retrospective studies of mortality in captive carnivores. It would be important to compare this prevalence in African wild dogs with other institutions in order to identify management differences that could be applied to reduce cannibalism, as it appeared to be a significant limiting factor of population growth.

Close medical supervision is also recommended in adults to diagnose early chronic kidney disease and medicate them as early as possible to limit the onset of this disease. Close monitoring of reproductive function is also vital in adult females, especially if under contraception. Surgical sterilisation of non-reproductive females could also be recommended in order to reduce further reproductive disorders. Finally, further work should be done to

investigate the prevalence of neoplastic diseases in African wild dogs as they seem prone to them. Similar studies could also be done for all facilities that house African wild dogs in order to better redefine husbandry guidelines for this species.

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